FOURTEENTH ANNUAL REPORT

OF THE

Quebec Society for the Protection of Plants

1921-1922

Supplement to the report of the Minister of Agriculture

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QUEBEC

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Quebec Society for the Protection of Plants

1921-1922

To the Honourable J. E. Caron, M.P.P.,

Minister of Agriculture,

Quebec.

Sir :—

I have the honour to present herewith the fourteenth Annual Report of the Quebec Society for the Protection of Plants, containing the proceedings of the winter meeting of the Society, which was held at Macdonald College, Ste. Anne de Bellevue, Que., on the 24th of March, 1922.

Included are the papers that were read, and the reports of the officers of the Society.

I have the honour to be,

Sir,

Your obedient servant,

B. T. DICKSON,

Secretary-Treasurer.

Macdonald College, Quebec.

QUEBEC SOCIETY FOR THE PROTECTION OF PLANTS

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Delegates to the Canadian Branch of the American Phytopathological Society, Dr. B. T. Dickson and Prof. G. R. Cosette.

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Petch, C. E.	Hemmingford, Que.
Petraz, Mr.	Horticultural Service, Quebec.
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Summerby, Prof. R.	Macdonald College.
Swaine, Dr. J. M.	Entomological Branch, Dept. of Agr., Ottawa.
Tawse, W. J.	Macdonald College.
Tessier, G.	Forest Service, Quebec.
Victorien, Rev. Bro.	University of Montreal, Montreal.
Willey, Dr. A.	58 Metcalfe St, Montreal.
Winn, A. F.	32 Springfield Ave., Westmount.

HONORARY MEMBERS

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Hon. J. E. Caron, M.P.P., Minister of Agriculture, Quebec.
F. C. Harrison, D.Sc., Macdonald College.
Rev. Father Superior, Dom Pacome Gaboury, La Trappe, Que.
Auguste Dupuis, Village des Aulnaies.
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Rev. Father Superior, Ste. Anne de la Pocatiere.
J. C. Chapais, D.Sc., St. Denis-en-bas, Que.
A. Gibson, Esq., Dominion Entomologist, Ottawa.
Hon. Minister of Crown Lands and Forests, Quebec.

FINANCIAL STATEMENT

QUEBEC SOCIETY FOR THE PROTECTION OF PLANTS

Receipts

Brought forward	$ 152.42	
Provincial Government Grant	250.00	
Interest on deposit	7.31	
		$ 409.73

Disbursements

Lectures and delegates	$ 56.45	
Delegates to Ont. Entom. Soc	67.60	
Delegate to Canadian Phytopath. Soc	37.60	
Delegate to Royal Society	12.50	
Secretary	50.00	
Postage and typewriting (1920-21)	24.57	
Expenses of annual meeting	19.00	
Index Generalis	6.21	
Balance on hand—May 16th	135.80	
		$ 409.73

Auditor :—

E. MELVILLE DUPORTE,

B. T. DICKSON,
Secretary-treasurer.

W. LOCHHEAD,
President.

REPORT OF THE WINTER MEETING

The fourteenth annual meeting of the Quebec Society for the Protection of Plants was held in the Biology Building of Macdonald College, on Friday, March 24th, 1922.

Business Meeting

The business meeting was opened by the President, Prof. Wm. Lochhead, at 11.00 a. m. Among those present were:—Rev. Father Leopold, Dr. F. C. Harrison, Prof. F. E. Lloyd, Dr. J. M. Swaine, Dr. B. T. Dickson, Dr. E. M. DuPorte, Dr. G. McRostie, Prof. T. G. Bunting, Dr. J. F. Snell, Mr. C. E. Petch, Mr. W. Tawse, Mr. Winn, Mr. F. H. Grindley, Mr. Coderre, Mr. Blair, Mr. Howitt, Mr. W. N. Keenan, Mr. A. G. Dustan, Mr. T. G. Major, Miss D. Newton, Mr. J. K. Richardson, Mr. Dunn, Mr. Lachaine, Mr. Shepherd, Mr. Gordon, Mr. Hale, and others.

The minutes of the last meeting were approved.

The report of the treasurer was read and accepted.

The following were the officers appointed for the following year :—

President:—Prof. Wm. Lochhead, Macdonald College.
Vice-President—Rev. Fr. Leopold, La Trappe.
Secretary-treasurer:—Dr. B. T. Dickson, Macdonald College.
Directors:—C. E. Petch, Esq., Hemmingford, Que.
Prof. G. R. Cossette, La Trappe.
A. F. Winn, Esq., Montreal.
Rev. Prof. Fontanel, Montreal.
G. Maheux, Esq., Provincial Entomologist, Quebec.
G. Chagnon, Esq., Montreal.
G. Bouchard, M.P., Ste-Anne-de-la-Pocatière.
Dr. A. T. Charron, St-Hyacinthe.
Auditor:—Dr. E. Melville DuPorte, Macdonald College.
Delegate to the Royal Society of Canada:—Prof. W. Lochhead.
Delegates to the Ontario Entomological Society:—Prof. W. Lochhead and Rev. Fr. Leopold.
Delegates to the Canadian Branch of the American Phytopathological Society:—Dr. B. T. Dickson and Prof. Cossette.

It was resolved that the Society, so far as funds are available, continue to help in aiding investigations concerning economic diseases caused by insects fungi, or bacteria.

It was resolved that letters of condolence be written to the relatives of the following members, deceased during the year, whose absence will be felt by the Society:—Rev. Dr. Robert Campbell, Rev. Dr. Thos Fyles, and Mr. L. Gibb.

It was unanimously resolved that Dr. J. C. Chapais, Mr. A. Gibson, and Abbé Dom Gaboury be made Honorary Members of the Society.

The continued increasing demand for copies of the Report of the Society from other Societies, Universities, Colleges, Experiment Stations, etc., was reported by the Secretary and was considered very satisfactory. It was explained that the type of article in the Report was intended to suit as far as possible the needs of a wide reading public.

It was decided to postpone the summer meeting until December, in order to meet in conjunction with the Canadian Branch of the American Phytopathological Society, which is holding its annual meeting at Macdonald College.

GENERAL SESSION

The general session of the fourteenth annual meeting was opened at 2.00 p. m. by the President, Prof. W. Lochhead. The addresses and papers are printed in detail in the body of the Report. The guests of the Society were Dr. C. D. Howe, Dean of the Forestry School of Toronto University, and Dr. J. H. Faull, Head of the Department of Botany of Toronto University.

Dr. F. C. Harrison, Principal of Macdonald College, extended a cordial welcome to the delegates and members and especially welcomed our guests from Toronto University.

THE PRESIDENT'S ADDRESS

SOME EARLY FOREST ENTOMOLOGISTS

By W. Lochhead, Macdonald College

Ladies and Gentlemen :—

This is the fourteenth annual meeting of the Quebec Society for the Protection of Plants. Organized in 1908, this Society has endeavored to foster the investigation of those insect and fungous agents that hinder the development of plant life and to make available to all persons interested in the preservation of plants, whether they be forest or shade trees, or field and garden crops, reliable information regarding the best methods of treatment in the form of an Annual Report. The membership has never been a large one, but it is thoroughly representative of both the French-speaking and the English-speaking peoples of the Province.

In the fourteen years of the society's existence, several members have been lost by reason of removal to other provinces, and several have been lost by death. The death of Dr. Gordon Hewitt, Dominion Entomologist, in Feb. 1920, was a severe blow, and the recent deaths of Dr. Robert Campbell,

of Montreal, and Dr. Thomas W. Fyles, of Ottawa, in 1921, remove two charter members and active workers whom the society can ill afford to lose. Still more recently we have to lament the death of Mr. Lachlan Gibb, of Montreal and London, England, who found time, during his occasional visits to Montreal, to attend our annual meetings.

As the papers and discussions at most of our meetings have been largely devoted to the consideration of the enemies of field, orchard and garden crops, the Executive Committee considered it advisable to put on a programme this year that would make a special feature of forest and shade trees. No one nowadays questions the importance of our forests as a great natural resource, but the truth has been forced upon us in recent years that this supposedly illimitable forest supply is becoming perilously endangered and that it is only a matter of a few years before the forest areas will fail to supply the demand upon them unless strenuous measures be taken quickly to control reckless cutting, the insect and fungous enemies and fire and to initiate a vigorous policy of replanting. These matters will be dealt with at length by the speakers whose names appear on the programme, and there is no need for me to say more along this line at this time.

———

This is my fourteenth Presidential Address, and I have attempted in every address to discuss some topic of general interest to the members of the Society. This time I shall take the liberty of presenting a few notes on the forests entomologists who have made large contributions to the science of forest entomology—the men who laid the foundations of our knowledge of forest insects.

We must look to Europe for the first investigations into the life and habits of forest insects, for there first was felt the need for action looking toward the conservation of forests.

These investigations do not date very far back—in fact less than a hundred years. The most prominent workers were Kollar, Ratzeburg, Eichhoff, Kaltenbach, Perris, Nordlinger, Henschel, Taschenberg and Judeich and Nitsche. In Germany and France, Forestry Schools were established early and in all of these forest entomology was studied.

In any consideration of the investigators of insects affecting trees, we have to distinguish between those men who were mostly systematists and those who devoted most of their studies to the life and habits of the insects. The former group contains a larger number of workers than the latter. To such belong *Linnaeus* (1707-1778) who gave us the system of binomial nomenclature, and was perhaps the greatest among systematists. *Fabricius* (1748-1808) a Dane, was also a great systematist and described a large number of forest insects. *Réaumur* of France (1683-1757) and *DeGeer* (1720-1778) of Sweden, combined a study of life and habits of insects with that of description, and both left important works which belong to the great classics of entomology. The Englishmen *Kirby, Leach* and *McLeary*; the Frenchmen *Guenée, Latreille, Bonnet* and *Olivier*;

the Germans *Zimmerman* and *Gyllenhal*; and the Americans, *Say, Harris, Fitch, LeConte, Walsh, Packard, Riley* and others have all described many species of insects infesting trees.

In the second and smaller group of forest entomologists, the earliest were J.M. Bechstein and G. L. Scharfenberg who published in 1804-1805 a "Complete History of the Harmful and Useful Forest Insects". In 1818 Bechstein published a revised edition of this work. E. Thiersch published in 1830 a work on Forest Beetles, with special reference to the Bark Beetles. V. Kollar published in 1837 a Natural History of the Injurious Insects in Agriculture and Forestry, which is still consulted. The greatest name in the list, however, is that of Ratzeburg who laid the foundation of forest entomology upon which all succeeding workers have built. His works are classic masterpieces.

LIFE OF RATZEBURG

Julius Theodor Ratzeburg was born in 1801 at Berlin. As a boy he received instruction in Botany from his father, a professor in the Veterinary School. Owing to the death of his father in 1808 and the remarriage of his mother, he went at the age of 12 to live with his uncle Wutzke at Koenigsberg where he attended Frederick College for a time. Later he attended the Lyceum in Posen and the "Gray Cloister" Gymnasium in Berlin. Even in his school days he showed great aptitude for drawing. His inclination to Natural Science was shown in his sudden resolve at this time to become an apothecary, and as an apprentice he served in the Laboratory of Wendland in Berlin. His spare time was utilized in various scientific researches in the large Berlin Gardens. This sort of work was unsatisfactory for he saw that an essential part of Natural Science was Zoology and Anatomy to which he was a stranger. Consequently, in 1821, he enrolled as a student in medicine at Berlin. He took his degree in 1825, obtained permission to practise his profession in 1826, but he did not care to practise, so he remained at the University.

Ratzeburg had the good fortune to come into close touch with many important persons of the day. His student companions Brandt, Goeppert and Phoebus remained his life long friends, and as a private teacher he became acquainted with the Humboldt family. When the new Forest Academy of Neustadt-Eberswalde was opened in 1830, he was appointed to the chair of Natural science, which onerous position he held for nearly 40 years. At the outset Ratzeburg recognized clearly that the Natural Sciences should be taught from the standpoint of forestry, and he guided his instruction accordingly. He emphasized Entomology rather than Botany, for he saw clearly the great economic value of the study of forest insects, and the corresponding need for more detailed knowledge of these enemies.

To the study he devoted himself unselfishly and untiringly. In 1832, he wrote "The Development of Foot-less Hymenopteran Larvae", and in 1834 "Entomological Contributions". In 1835 he began his most important literary

work: "Forest Insects"—Part I, appearing in 1837, Part II, in 1840, and Part III, in 1845. This great work was the result of ten years of uninterrupted study of many widely-scattered notes on forest insects and of ten years of personal and correspondence touch with foresters, forest people and forest insects.

In the years 1844, 1848 and 1852 appeared "The Ichneumons of Forest Insects" in three Volumes, perhaps the best known of Ratzeburg's works——especially to entomologists.

Realizing that his "Forest Insects" would be too expensive for the average library and student, Ratzeburg had prepared a smaller book—"Forest Destroyers and Their Enemies". This book was published in 1841 and had reached its 6th edition in 1869.

Ratzeburg's plan was to investigate not only all injuries to trees by insects, but those resulting from physiological and pathological causes. To this end, he published in 1862 "The Diseases and Reproduction of the Pine as a Result of the Attack of the *Trachea piniperda*, the Forl-Eule", but he soon realized that it was impossible for any one man to deal adequately with the Physiology and Pathology on account of the rapid advances that were being made in these sciences at that time.

In 1866 he published Part I of a magnificent work entitled "Forest Injury or Losses inflicted by Insect Attacks, etc." Part, II, appearing in 1868.

In May 1869, after 39 years of most useful, unselfish activity as a teacher, Ratzeburg took a well-earned rest; moreover, his health rendered such a proceeding necessary. Already he had begun another work entitled "A Forestry Lexicon for Authors", and the manuscript was ready for the press at the time of his death in October 1871. This work appeared in 1872.

Beside the list of publications that have been mentioned, Ratzeburg published several smaller works on allied botanical and zoological subjects.

In the words of Phoebus, his life-long friend, "he erected a Dankmal, a monument more lasting than brass". It is not exceeding the truth to say that Ratzeburg's work stands as the greatest single contribution to forest entomology. Judeich and Nitsche's work on Forest Insects is a revision of Ratzeburg's great work, just as Escherich's work is a revision of Judeich and Nitsche's.

Parasitic Insects

According to Professor Trotter, the first person to divine the importance of parasites and predaceous insects and to apply the principle successfully was Boisgiraud of Poitiers, in France. About 1840, he freed the poplars in the suburbs of his town of Gypsy Moth by placing the *Calosoma sycophanta*, and he destroyed forficulids in his own garden by using *Staphylinus oleus*.

These successes seem to have inspired the Milanese to offer a medal to be given in 1845 to any person who had in the meantime conducted successful experiments in the artificial breeding of carnivorous insects which may be

used advantageously to destroy insects injurious to agriculture. To this appeal Antonio Villa responded in 1844 with a pamphlet entitled "Carnivorous Insects Used to Destroy Species Injurious to Agriculture", in which were set forth at length the results of successful experiments carried on by him at Desio, in the province of Milan. In these experiments carabids and staphylinids were used. Villa's results were criticized by Bassi, Bellani and Ratzeburg. The latter said:—"Carnivorous insects can be applied to the needs of agriculture only by the beneficient hand of nature and every effort to assist it must be in vain!"

In 1850 Rondani, an Italian, began his important researches on insect parasites and published a work entitled "An account of Parasitic Insects and Their Victims". He was of the opinion that parasites are of greater value than birds in the control of insects.

Perris, of France, published an important monograph in 1857: "The History of the Insects of the Maritime Pine". He noted the importance of parasitic and predacious insects in the destruction of wood-eating and leaf-eating forms.

DeCaux, also of France, about 1872, did much valuable work on the utilization of parasites in the fight against injurious insects.

E. L. Taschenberg published in 1866 a valuable work on The Hymenoptera of Germany, in 1874 a work on The Natural History of Insects Injurious to German Forests, and in 1880 a work on Practical Entomology.

G. Henschel published in 1861 and 1876 a "Guide to the Determination of Injurious Forest Insects, with information as to their life history and means of control".

J. H. Kaltenbach published in 1874 a "Handbook of Insects for the Use of Agriculturists, Gardeners and Foresters".

To Eichhoff we are indebted for an excellent work on European Bark Beetles (1881). He not only described many forms but discusses the bionomics of the group. He said that "the most favorable conditions for the increase of these beetles are doubtless a warm early spring and a warm summer with frequent rains and a long mild autumn". Other contributing factors are strong winds, snow, frosts, forest fires, the devastation brought by caterpillars, whereby the trees are more or less decorticated in places and otherwise wounded (Packard)".

For many years, the only work of importance on Forest Insects published in America was that of Packard, published in 1886-1890.

In 1905-1906 Dr. E. P. Felt published a valuable work in two volumes on "The Insects Affecting Park and Wood land Trees". The work of Doctor Hopkins in the United States and Dr. Swaine in Canada is of tremendous value, but this cannot be treated at this time.

FOREST PATHOLOGY IN RELATION TO FOREST CONSERVATION

By Dr. J. H. Faull, Toronto, Univ.

The forests of Canada have been a notable heritage, a wide-extended covering of magnificent trees of many kinds; they have provided a shelter for game and fur-bearing animals, a protection for the watersheds, playgrounds for the people, an unending storehouse of wealth and a continuous and unmeasurable source of spiritual power. For the main part they have remained in the ownership of the people, the state; thus it is that their conservation is of direct interest to and a responsibility of every citizen of the country.

Three agencies have been very active in destroying this heritage—waste, fire, and disease, and with such effect that there is a very real danger of an

FIG. 1.—Scene in a Quebec pulpwood forest after harvesting. This area has been severely damaged by the spruce budworm and the timber-destroying fungi that follow the spruce budworm.—(Photograph by courtesy of O. Schierbeck.)

asset being converted into a liability. Conservationists have been prophesying for many years the approaching exhaustion of our forests. There has been a tendency to call their assertions into question, or at best to accept them with a mental reservation; the conditions we now face are a complete vindication of their gravest warnings. We are all too familiar with endless barren wastes once clothed with forests and with the increasing remoteness of profitable timber; but few even yet realize that over vast stretches the pines have become almost literally, certainly practically extinct, that the spruces are rapidly

disappearing in the same way, and that the once despised balsam is most seriously threatened; yet such is the case.

The gravity of the situation is now impelling attention along two lines of action, namely *utilization* and *restoration*, the making best use of what remains, and the re-establishing of a forest cover over the despoiled wastes, or, in brief, the adoption of purposeful and beneficial systems of forest management. Happily the fundamental necessity of *protection* has already been recognized and is being practised; so the way has been prepared for the formulation of policies of regulation.

The ideal regulated forest is a healthy forest; we are starting towards that ideal with extremely decrepit forests. The undisturbed virgin forests in the aggregate probably exhibit a balance between disease and accretion, but through the interference of man, the stronger healthier trees of our forests in general have been removed, sanitation has been neglected, and as a result, the normal tone has been distintly lowered. Therefore it is not surprising to discover that a large proportion of the problems of the transition period which we anticipate will culminate in regulated forests are problems of forest pathology. Many of them are of fundamental importance in relation to fire protection, utilization, productivity, stumpage values and type successions.

The role of forest pathology in the planted forests of Europe is clearly defined; European foresters remove weak and infected trees from their plantations, and the rangers are taught to recognize and instructed to destroy the fructifications of disease-producing fungi. Campaigns against specific fungi have at times been organized and carried through successfully. The case is similar with regard to nurseries, parks and street trees; in such locations spraying can be profitably adopted and even individual trees can be medicated or placed under the surgeon's saw and chisel.

But it is very different with our great untamed American forests. It is plain that the methods applicable to plantations and nurseries are unsuited to them; their problems, often complicated, demand separate and special consideration. By way of concrete examples of representative problems solved or under investigation, let me cite three types drawn from work in Ontario—(*a*) the needle blight of the white pine, a special problem with reference to a cutting policy, (*b*) a study of the heart rot of birch, a problem relating to the utilization of this wood for purposes demanding maximum strength and (*c*) studies on butt and heart rots, a complex of problems affecting almost evey phase of forest management.

(*a*) **Needle blight of the white pine.**

Among the special problems that have been called into review in Ontario, particular attention has been given to the needle blight of the white pine. This malady is especially prevalent in some of the white pine stands of northern Ontario, and though perhaps not so frequent elsewhere, may be found to occur in any part of the Province. An investigation was undertaken in 1918 and

continued in subsequent summers at the request of the Forestry Branch of Ontario for the purpose of determining its nature (especially whether or not it be contagious) and its effects on pine stands suffering from its attacks. The existence of this disease appears to have been reported to the Branch for the

FIG. 2.—A severely and repeatedly needle-blighted white pine at the right; a healthy white pine at the left.

first time from the Timagami Forest Reserve in 1905, and again from the same area in 1908, 1912, 1913 and 1917. Mr. C. E. Hindson, Chief Ranger of the Timagami Forest Reserve, wrote in August, 1912, stating that "a large number of pine trees in the vicinity of Timagami Lake have turned brown and appear to be dying." The greater part of the research has been carried out in Timagami, an area located about 300 miles north of Lake Ontario.

The most striking of the symptoms of blight consist of a yellowing or reddening of the new partly-grown needles very shortly following their emergence from the buds, an event that occurs in late June or the first part of July. The discoloration continues progressively from the tips of affected needles downwards over an interval of about two weeks. The upper part of the tree is usually most severely affected although all parts are commonly involved. The extent of the blighting is most frequently uniform for all needles of any single fascicle, and shows itself in varying degrees up to totality.

It was soon ascertained that the injury was not a winter killing of the foliage, an enzymatic disease, or due to fungi or insects, nor could it be induced in healthy branches by fusing them at freshly abraded spots with diseased branches of affected trees. It was discovered in 1919 that the trouble lay in the roots, that the absorbing roots were largely dead in blighted trees, as a result of which, at the time the new needless are expanding there is a sudden demand for a greatly increased supply of water which cannot be delivered. Consequently the young needles turn pale and then redden from the tips downwards. The foliage of trees recovering from blight in later years may be short, tufted and pale, but there are other factors to be considered in that connection. The cause of the killing of the absorbing roots has not been fully demonstrated, but there is evidence to show that it may be brought about by a drying out that takes place in periods of drought in shallow or leachy soils. Owing to the dry weather experienced in the summer of 1921, the blight, while not as abundant in Timagami as in 1918, was more sharply defined than in 1920.

But white pine (*Pinus strobus*) is not the only tree affected in the blight areas, although it probably suffers much more severely than other types; proof is accumulating that shows that other timber species are involved to a greater or less extent, depending on their relative susceptibilities.

The question of needle blight has come into consideration in relation to another problem, namely, the possibility of distinguishing between needle blight and discolorations due to sulphur fumes in areas within the possible range of sulphur dioxide emanations. They can be differentiated during the growing season, but probably not at any other time. Observations on both phenomena have shown that burning of the leaves from sulphur fumes takes place rapidly and whenever conditions of temperature and humidity are favorable, and the injuries are not necessarily restricted to the needles of the current season, although these are the ones that are most susceptible. As has been seen, needle blight occurs at a definite period in relation to the emergence of the needles from the buds. In the early spring, that is, before the buds break, it is doubtful if it be always possible to distinguish with certainty needle blight from winter browning or from injuries due to sulphur fumes.

Observations on the needle blight have now been carried on for four years, and the status of 633 white pine trees whose histories have been followed since 1918 is summarized in the table that follows.

Blighted trees studied 358
Checks (healthy trees) 275

Of the checks two only have developed blight and under known conditions. They blighted in 1919 following partial lifting of the thin soil cover and its permanent displacement from the bed of coarse broken rock on which it lies —the action of ice. These trees died in 1921. The blighted trees have been divided into two classes; (1) Those with trunks 6 inches or less in diameter, b.h. (II) Those with trunks more than 6 inches in diameter.

Blighted in 1918		Died			Total per cent dead	Showing blight in 1921	Apparently recovered	Doubtful
		1919	1920	1921				
I	147	2	6	2	6.8	24	105	8
II	211	12	20	18	23.7	80	44	37

From the results obtained it is reasonable to conclude (1) that young stands are not likely to be seriously depleted by needle blight; (2) that injury to heavily blighted mature stands may be so great as to be a deciding factor in determining the time of harvesting; (3) that in regions subjected to sulphur fumes, it is possible to differentiate between blight and sulphur fume injury if the examination be made at the right time; (4) that the malady is not contagious and hence is solely of regional importance.

(b) **A heart rot of birch.** (*Fig. 3*).

A special case calling for an investigation of the heartwood of birch, normal in appearance but weakened from some unknown cause, was undertaken some months ago because of complaints of manufacturers using this wood for spokes and other purposes demanding maximum strength. A preliminary examination showed that this was due to a common fungus the relationship of which had not heretofore been worked out, namely the true tinder fungus, and that wood for the purposes mentioned should not be taken from certain types of defective trees easily recognizable in the forest.

The true tinder fungus attacks standing or fallen beech, birch, poplar and occasionally elm, causing a whitish decay. It is readily recognized by its fruiting-bodies or sporophores, the grayish hoof-shaped punks or brackets so common on the trunks of its hosts. Most frequently this fungus works from the crown down, though not invariably so. The true tinder fungus abounds throughout Ontario, and is also frequent in the adjoining states. Von Schrenk & Spaulding (Von Schrenk, H. & Perley Spaulding: Diseases of Deciduous Forest Trees,

Bull. No. 149, Bureau of Plant Industry, U.S. Dept. of Agr., Washington, 1909) report that "In northern New-England, New York, Michgan, Wisconsin and Minnesota in particular, the tinder fungus (*Fomes fomentarius*) is one of the commonest wood-destroying forms found in deciduous forests."

Botanically many new points of interest have been noted—such as the characters of its spores, their viability and method of germination, the remark-

FIG. 3.—*Fomes fomentarius* on trunk of a living yellow birch.

able habit of vernal spore discharge, and the production of spores for three or four years from the same pore layers. But the main interest here centers on the relationship to its host. Regarding this feature, a general misconception has existed and one that directly concerns the application of the heartwood to some industrial purposes. Various manuals or bulletins dealing with the fungus ascribe to it a decay in the outer sapwood of living trees immediately

under the bark, from there working inwards. An examination of hundreds of affected trees has failed to substantiate this view in any one instance. On the contrary, in living trees the fungus enters through wounds or broken or dead stubs and penetrates to the inner sapwood and heartwood, rapidly spreading up and down in these regions of the stem and more slowly outward towards the bark. In birch it appears to spread more abundantly and rapidly in the inner sapwood, but it is important to note that the adjoining heartwood is also affected and in consequence weakened. One of the most significant features is the circumstance that cured timber from trees in which the decay is in its

FIG. 4.—A section of yellow birch attacked by *Fomes fomentarius*. The section was placed for some days in a moist chamber. A strong development of the mycelium, which darkened in time, appeared as indicated in the blackened zone of the photograph.

incipient stages is indistinguishable by ordinary means of examination at the command of the user, from perfectly sound timber. The infection of the birch appears to be commonly associated with the breaking of the branches of the crown due to the action of a boring insect. (*Fig. 4*).

(*c*) **Butt and heart rots.**

Butt and heart rots constitute the outstanding destructive agencies at work in our forests. No forest is exempt, and every mature stand becomes more and more susceptible with increasing age. The time inevitably comes when they bring about an accelerated loss of stumpage values through deterioration. They are also responsible for most wind-falls and consequently for

the vast amount of debris that litter the floors of our forests, affording a limitless supply of highly combustible waste material, and finally butt and heart rots are dominant influences in relation to the succession of cover types in unregulated forests. Fortunately they are almost altogether restricted to mature or suppressed timber; young trees are practically immune. This fact greatly simplifies the problems of control and gives assurance that they will be largely solved in the administration of any good policy of forest management.

One of the unexpected drawbacks encountered in investigating butt and heart rots has been the lack of information on even the identity of the causal

FIG. 5.—A common scene in an over-mature forest. Both the red pine and the balsam at the lower right were severely butt-rotted. Not infrequently a large proportion of the affected trees in such areas are brought to the ground by the wind or their own weight.

organisms. Balsam rots may be cited as an extreme case; though several types occur in living balsam trees, nobody as yet, so far as the literature shows, has definitely established a connection with a specific causal factor in any single case. To help meet this situation investigations were began two years ago, and are now being carried on with fruitful results. The methods employed include those so successfully used in cultural diagnostic studies of bacteria.

But there are other fundamental problems of even greater importance calling for solution, such, for example, as the rate of progress of heart and butt

rot infestations, the relations of these diseases to the age of the host species, to the specific resistance of the host and to environmental factors. And here we would include such topics as soil characters, crowding, mixed stands and climate, all of which have a direct bearing on the relation of heart and butt diseases to yield and hence to the questions of reforestation and harvesting.

Such experimentation moves slowly. True, but it will be readily conceded that the exploitation and neglect of half a century cannot be repaired in a day. The solution of the problems of our unregulated and unscientifically treated forests will demand time, patience and a force of trained investigators. But every problem solved will be of value in the administration of and will contribute to the welfare of the forests of to-day and to-morrow.

OUR FOREST CONDITIONS AND SOME OF OUR FORESTRY PROBLEMS

By Dr. C. D. Howe, Toronto University.

A detached observer, looking upon the affairs of men, would note the occurrence of definite periods of confidence and fear, boastfulness and humility, periods of enthusiasm and high endeavor, periods of depression and futility. These periods recur quite regularly in cycles; they recur in cycles in the individual's life and in the nation's life. The causes are not well understood: they may be environmental or they may be psychological or both. Too often, they may be chiefly psychological. Since the psychology of the industries is largely the psychology of the people concerned in them, they, too, exhibit cycles of buoyancy and flaccidity, of prosperity and poverty, cycles of aggressiveness and timidity.

With these general observations in mind, let us turn to our wood-using industries, or rather the sources of supply of raw materials for those industries, the forests, and inquire through what periods the attitude of the people, the national psychology, has passed with regard to them.

In the first place, we are all familiar with the fact that the forests must give way to agriculture. In the early days, the pioneer and the forest were enemies because, at that time, the settler could not get the necessities of life from the forest, but the products of the farm were entirely sufficient for his simple wants. The quickest and easiest way to get rid of the forest was to burn it. What a story it has been! What a record of achievement! When one beholds the wide rolling uplands of Ontario, the fertile meadows of the St. Lawrence valley, and the green fields in the provinces down by the sea, he is lost in admiration for the sturdy pioneer who destroyed the forest to create the farm. You know ours is a vast country with a small population and, therefore, we are still in the pioneering stage. Within less than 100 miles of Montreal one still finds the settler clearing the forest to make a farm. Within

a few hours by rail from any of the large cities of Canada, one may find the pioneering development of farms and mines on a large scale. Forest conditions have changed. The value of the forest has increased enormously in the past 100 years, but unfortunately the mental attitude of the pioneer has not materially changed. A large percentage of the destructive forest fires in Eastern Canada are caused by the carelessness of the settler and prospector. If we include those chargeable to the pioneer railways, then we may say that much the greater portion of the forest devastation is attributable to the pioneer spirit. Our forests suffer grievously from the inertia of a fixed idea.

During the early eighties a remarkable wave of enthusiasm for forest conservation swept over Canada and the United States. It took the form of fire protection legislation, tree planting on arbor days, and the establishment of forest plantations. Among the leaders of the movement in Quebec were Sir Henri Joly de Lotbinière and Mr. William Little, whose names public spirited people still revere. At this period there was much discussion of the approaching exhaustion of the timber supply. One writer lamented the fact that the pine logs in the drives would yield deal boards only two feet wide compared with the logs of previous years that would square from two to three feet. Mark the dimensions, those of you who have seen the log drives of recent years! A prominent lumberman predicted that the supply of pine in Quebec would not last more than 25 years. Over 60 million feet were cut in the Province in 1920, which shows there is still some pine left. Yet the lumberman was right. Using the standard of his time, his prediction came true. Forty years ago only the largest and finest trees were taken. It apparently never occurred to thim that it would ever be profitable to use trees less than two feet in diameter. He couldn't have imagined the use of small pine logs for laths and matches.

During the next period the pendulum of public opinion with regard to the forest resources swung far in the other direction. It was a time of great industrial development and of increasing prosperity. Owing to increasing demand, timber values mounted rapidly. Fortunes were made in timberlands, more often, however, by the speculator than by the actual operator. Yet great business organizations were built up by sagacious and public spirited men. Their achievements stand high in the annals of Canadian industries. Quite naturally, however, there developed a feeling of over confidence with considerable expansion in the thoracic region. Our forests are illimitable and their supplies inexhaustible. Why worry? All talk of the necessity of husbanding the forest resources is the blank-edest nonsense. It was an unpopular thing to say ought to the contrary. Indeed, some of the prominent conservationists of the time were publicly accused of being unpatriotic and of attempting to check the industrial development of the country. Unfortunately, some of these unfounded conceptions have persisted down to the present time, having been kept alive by the unthinking but loquacious politicians on the hustings and having been perpetuated even in school textbooks. Let me say,

again, that our forest resources have suffered grievously and in the future will suffer still more grievously from the inertia of a fixed idea.

Gradually the reaction from the feeling of over-confidence with regard to forest supplies set in. The hinterlands were being explored and the notion that they were densely forested was exploded. The effect of the awful devastation by forest fires on future supplies was slowly soaking into the public conscience. This feeling of uncertainty as to the future was common to Canada and the United States and it culminated in the establishment of Commissions of Conservation in both countries in 1908 to 1909.

The Commission in the United States was established before that in Canada, but ours lived longer, being strangled to death only last year. The leaders in the United States were such men as the then President Roosevelt, Gifford Pinchot, Judge Taft, and in Canada, the then Premier Sir Wilfrid Laurier, Sir Clifford Sifton and the late Senator Edwards. The period was characterized by a stock-taking of all resources—a very simple and fundamental idea, the first step in any private business organization, but one that, for some obscure reason, always meets with opposition, especially from politicians, when applied to public organizations. We shall never know what it is necessary to do for our forests, for example, until we know what we possess in terms of present capital stock and its rate of natural accretion in relation to the present and probable future harvests of timber and pulpwood. The late Commission of Conservation was the only organization that ever attempted such investigations on a Dominion wide basis—and it was cut down in the dark before its work was completed.

After the Great War we were very humble, but at the same time very proud of the Empire's achievements. We are finding out by sad experience in our industrial and social relations that some of the most important results of the war were not the most obvious at the time of its cessation. Among other things the war taught us the value of the Empire's forests and, as you know, the Canadian Forestry Corps was a very important factor in winning the war. The importance of the forest as an auxiliary unit in warfare led Great Britain to establish a Forestry Sub-Committee as a part of its great Reconstruction Committee that did such magnificent work in meeting the changed requirements of peace. The Forestry Committee reported upon the forest conditions in all parts of the Empire and formulated plans for a great reforestation program, involving the planting of 1,700,000 acres and the expenditure of $75,000,000. In the case of Canada, after pointing out the dependence of Great Britain upon the forests of the Dominions, especially those of Canada, describing the efforts of the various forestry organizations, and urging the extending and the speeding up of their work, the Committee makes this statement: "The forest capital of Canada is growing less year by year. This, we submit, is an Imperial question of first magnitude which deserves immediate attention of the Imperial and Dominion Governments." As the result of the recommendations of this Committee, an Imperial Forestry Conference was

held in Great Britain in the summer of 1920. Six delegates attended from Canada, Quebec's representatives being Ellwood Wilson, Chief Forester to the Laurentide Company, and Mr. Bedard, Assistant Chief Forester to the Quebec Government. Among other things, the Conference recommended complete surveys of forest resources in the various dominions and the gathering of data on the rate of growth and regeneration. It stated that such data were absolutely essential to rational and economic management of the forests.

The Imperial Forestry Conference marks another period in the history of our forest treatment. The direct interest of the Empire in how we manage our forests; that is a very significant thing, capable, if sustained, of far-reaching consequences to the advantage of the forests and consequently to Canadian industries.

The characteristics of the present period developed gradually, however. The war had an accelerating effect and linked Canada up with the Imperial forestry needs. The beginnings of the present period were indicated some years ago in the management of extensive forest areas in the West by the Dominion Forestry Branch, in the employment of foresters by lumbermen and pulpwood companies, and in the development of reforestation programs. The Province of Quebec took the lead in the two latter. The first private companies to employ foresters are here. The first companies to begin planting operations on a commercial scale are in this Province. The Provincial Forester was perfecting his plans for cooperative planting on pulpwood limits before the Imperial Conference took place. I am informed that certain pulpwood companies are making the necessary investigation of reproduction and rate of growth preliminary to restricting the annual cut to the amount accumulated by the annual growth. Similar studies are being made in New Brunswick. Within the past few weeks, the Prime Minister of Ontario has announced his adherence to a reforestation program that calls for the planting of 10,000 acres a year for the next sixty years.

Now, why is it that private companies are going into the business of forest planting on a large scale? Why is it that Ontario is planning to reforest over a half million acres of waste lands? Why did the British Reconstruction Committee say that forest conditions in Canada presented an Imperial question of first magnitude which deserves the *immediate* attention of the Imperial and Dominion Governments? Let us hastily examine into our forest conditions to see if we can find a satisfactory answer to these questions. Before we proceed, however, let me point out a mistaken conception quite generally held by the public. People think that, if an area is covered with a forest of some kind, all is well. In our climate, they say, nature will always give us trees of a sort. Let us take what nature gives and not worry about the future. This assumes that all trees are so alike in their physical and mechanical properties that they can all be used, if necessity requires, for the same purpose. Any farmer or wood-user knows this isn't so, yet I have often heard the idea expressed by otherwise intelligent people who ought to know better. Quite

likely they talk that way because of the emolient properties of the idea. As a matter of fact, there are forests and forests; there are trees and trees. It does not follow that an area covered with forests is commercially valuable because of their presence, or that one tree is as good as another for the various purposes of the market. In the neighborhood of 70 different kinds of trees have been used in this country in the wood and timber trade, but a very few species contribute the greater portion of the output. About four billion feet of lumber are cut in Canada every year. Their value as rough lumber is approximately $122,000,000. When time, labor and thought have been expended upon them they become worth around $250,000,000. Thus our forests, in terms of the manufactured lumber products, increase our national wealth a quarter of a billion dollars each year. Over two-thirds of the above values are contributed by six different kinds of trees. The comparatively few kinds of trees in our forests that are utilized in large quantities are still more strikingly shown in the case of the pulpwood. Of this material around four million cords are cut each year, valued in the rough at $45,000,000, and from which pulp and paper products are produced to the value of over $200,000,000. More than 90 per cent of these values is furnished by the wood of four kinds of trees.

These few trees enter so largely into the products of the forest not because they are plentiful and accessible, but because they meet the market requirements better than any others. Because of certain inherent mechanical and physical properties, no Canadian wood, for example, is so well adapted to such a variety of uses as that of the white pine. The commercial supply of this species is fast disappearing. Owing to this fact, we are already using poorer woods as substitutes—with little or no difference in price. And again, no wood fibre is so well adapted for paper making as that of spruce. Notwithstanding all that has been said and done with regard to employing various vegetable fibres as substitutes for woodpulp, little has been accomplished or probably ever will be accomplished because of the quality, adaptibility and cheapness of production of wood fibre and among wood fibres those of spruce stand supreme as the result of certain inherent characteristics. When the supply of spruce is gone we shall be compelled to use poorer—but not cheaper—grades of paper.

Now we will turn to our forested areas from the standpoint of the commercially valuable trees. In the first place, of the 3.5 million square miles of land area in Canada, 1.6 million square miles, over 40 per cent, are too cold or too high or too dry to produce trees of sufficient size to interest lumbermen. Around 100,000 square miles should be deducted for agricultural lands outside the grasslands of the West, they having been included in the above. Even with these deductions, we have enormous areas covered by forests, some 1,900,000 square miles (over a billion acres), and again, having their utilization value in mind, let us ask: What kind of forests; what kind of trees? On at least 500,000 square miles climatic conditions are such as to produce only trees

of pulpwood size, practically no trees of sawlog size, that is 12 inches and above in diameter, except in the immediate river valleys.

Destruction of our forests by fire has been incomprehensibly great. The amount of saw timber thus destroyed has been much greater than the amount removed by logging or farming operations since the settlement of the country began, in fact probably greater than all that has been cut in the past plus all that could be cut today. There is little doubt that from one half to two thirds of the forested area of Canada, or in other words around one million square miles (640,000,000 acres) have been burned within the past 75 years and because of such fires do not today contain forests of sawlog size. This reduces the areas containing trees of sawlog size to about one quarter of the total forested area, that is around 500,000 square miles, or approximately 12 per cent of the land area of the country. If we had the population of the European countries or of the United States, this percentage would be far on the wrong side of the factor of safety. In fact, our supply of sawlogs would last the United States at their present rate of cutting not over fifteen years.

Just a little more about forest fires and their effect: Much of this million square miles has been burned not once only, but two, three or even a half dozen times. These repeated fires on the same area make abortive nature's attempt to reclothe the old burns with commercially valuable trees. Whole townships that once supported magnificent forests of pine or spruce are now, because of repeated burnings, covered with worthless brush or with trees of no market value. It is reported that you, in Quebec, have about two thirds of a million acres burned so severely that they are not producing the kinds of trees now being used for lumber or pulpwood. Such areas in Ontario are still larger according to reports. Bear in mind that these are merely estimates. They are not based on actual surveys, although surveys of the burned-over areas are being carried on in both provinces. I fear, however, we shall be simply appalled when the results of such surveys are made public. It is a matter of public record in Ontario, being disclosed by recent investigations of which you may have heard, that certain pulp and paper mills are finding it difficult to replenish from crown lands their waning supplies of spruce. And the reason is—repeated forest fires. This forest devastation by fire is not a thing of the past; it still continues practically unabated, except in wet seasons, in some of the most valuable forest regions of the country. Over a million and a half acres of forest fell prey to the flames in Eastern Canada last summer, but it was an exceptionally dry season.

Even on the areas which have been lumbered and have escaped burning, inferior trees usually take possession after the removal of the valuable pine and spruce, especially where they were mixed with hardwoods. I could show you areas both in Quebec and Ontario where old white pine stumps occur abundantly beneath the present stand of hardwoods or of mixed forest with practically no young pine trees to be found. The pine could not maintain itself after the logging operations. The conditions are considerably better where spruce

has been removed, but not nearly as good as they should be in order to produce a succession of future crops. You will see at once that in order to harvest a crop of trees on the same area, let us say at intervals of ten years, a sufficient number of trees must be ready at each interval to pay the lumberman for cutting them. When he cuts the 12 inch trees, for example, enough 11 inch trees should be left to furnish the next crop, enough 10 inches trees to yield a profitable crop at the third cutting, and so on down through the diameter classes, but with an increasingly larger number of trees in each diameter class downwards because the highest death rate is among the smaller trees. This is what foresters call the proper gradation of diameter classes and it is the basis of successive yields on the same area. Now, investigations have demonstrated that such proper gradation of diameter classes, especially in the smaller diameter classes, is lacking in the cut-over pulpwood forests of the mixed type (hardwoods and softwoods mixed) in Ontario, Quebec and New Brunswick, as revealed by intensive study of small representative areas. The trees that remain after the first, second and even third cutting belong to the virgin forest. They might be called the virgin surplus. When the lumberman cuts over an area ten years after his first cut, he thinks he is cutting the growth that has accumulated in the meantime, but he is not; he is simply cutting the virgin surplus, a part of the virgin forest that he did not take the first time because it wasn't profitable for him to take it. In fact, since the lumbering operations began in this mixed hardwood-softwood forest, say 50 or 60 years ago, there has not been enough regeneration of spruce eventually to replace what has been removed. In other words, the spruce as a tree of future commercial importance is being gradually crowded out of this mixed hardwood-softwood forest.

Under normal conditions forest trees die of disease. Very few die of old age. There is scarcely a healthy tree in a mature forest. Unfortunately, lumbering methods have been such as to increase rather than to decrease the susceptibility of trees to disease. Periodically there comes a combination of man-made and nature-made conditions that produces an epidemic in the forest. Just now the Eastern forests are being swept by a real scourge, the spruce budworm, which has already destroyed, according to the estimate of Dr. J. M. Swaine, 30 years' supply of pulpwood at the present rate of production. The destruction of wood material through such epidemics, however, cannot be adequately measured by the trees killed at the time because the after effects continue for years. The weakened trees becomes susceptible to fungus diseases to which they were previously resistant. The fungus bodies are like cancers. They dissolve away the tissues of roots or stem at the base of the tree until it is overturned by the wind.

Our forests, particularly the older stands, are rotten with fungus diseases. The number of trees that die before their allotted time is enormous and this has an important economic significance. This is an enormous waste of sawlog and pulpwood supplies that will be largely eliminated when conditions are such that our forests can be really managed. Balsam is one of the most susceptible

of the softwoods to fungus diseases. Dr. Faull, I believe, has found over 20 different kinds chewing at the vitals of balsam. This is the reason that we cannot depend upon this species as a source of pulpwood supply in the future.

We do not know as much as we should know with regard to the rate of growth of our forests. If the annual increase is as great as the annual loss, then the forests are self-sustaining and we have nothing to worry about. The chief object of all a forester's efforts is to get the area, over which he has charge, into that condition. Only by procuring a sustained and regulated yield can he furnish a continuous supply of raw material to the wood-manufacturing industries. That is what your Provincial Forester is trying to do. That is what the foresters of pulpwood companies, of which you have such splendid examples in this Province, are trying to accomplish. That is what the foresters all over Canada are striving for—the furnishing of an endless succession of wood crops for the lumbering and the pulp and paper industries.

Let me tell you some of the things we do know about the rate of growth in our forests. There are many misconceptions as to how fast trees grow in the nature habitat. Some one notices a fast growing forest tree in his field or garden , or in an open pasture and he concludes that trees in the forest grow at the same rate. In the one case, the tree is more or less cultivated and is not subjected to competition by neighbors; in the other case it is subjected to a severe struggle for life from the day it is born, and this expresses itself in retarded growth. I have made growth studies on several thousand trees in the mixed hardwood-softwood type in Ontario, Quebec and New-Brunswick, and I find that in the shade of the over-topping hardwoods, it requires about 30 years to make a spruce tree 1 inch in diameter; the average 4 inch tree is 60 years old; the average 8 inch tree is 120 years old, and the average 12 inch spruce tree is 150 years old. This is in nature's forest undirected by man. Human intelligence, by the proper manipulation of conditions in the forest, could reduce the time required to make a merchantable tree. That is the function of a forester. By planting the trees in old fields he could shorten the period to a much greater extent.

Now, with regard to the growth of the forest itself. Such studies as have been made are not encouraging. It has been found, for example, on areas in the mixed softwood-hardwood type, that have been cut over several times, spruce wood is accumulating at a much slower rate than it has been cut. In some cases as much spruce has been cut in the past 40 years as it took nature 250 years to produce. In other words, the annual growth in the past 40 years has been only one sixth as great as the harvest. It has been stated that if a single spruce tree 8 inches in diameter died on the average acre each year, the loss in wood volume thus ensuing would offset the average annual growth on certain cut-over pulpwood lands in Quebec. The Provincial Forester of Ontario estimates that the annual growth on the average acre of white pine forest in that Province has been only 15 board feet per year for the past 100 years.

This is the yield in board feet of a log 10 inches in diameter and 10 feet long according to the Doyle rule used for scaling logs in Ontario. He also estimates the annual cut of pine to be about one third greater than the annual growth. In fact the Government of Ontario paid back into the treasury $900,000 from the revenues derived from the forests on the assumption that at least that value of material had been taken from the forest capital stock and did not therefore in reality represent current revenue. The published reports indicate that certain pulpwood companies in Quebec have been doing a similar thing for the past few years, a transaction that can be interpreted as an acknowledgement that they are cutting their forests faster than they are growing. It will be seen, then, that such data as we have on the rate of growth in our forests indicate that the annual toll taken by the logging operations, by fire, disease and wind far exceeds the annual accretion of wood by the natural processes of growth.

Briefly, our forest conditions present this problem: Shall we accept for our lumbering and pulpwood industries the wood of constantly decreasing quality which nature unguided produces when the equilibrium in the forest has been upset by fire, disease or logging operations. or shall we exert intelligen effort to maintain our pine, spruce and other valuable forests and thus supply the forest industries with wood of incomparable quality particularly adaptedt to their needs?

It is both a challenge to human intelligence, a necessity from a business standpoint, and the part of patriotism to keep the natural forest areas continuously productive in terms of commercially valuable trees—trees whose products annually increase the wealth of the country by nearly a half billion dollars.

GNATS—BLACK FLIES—SIMULIA

By Dr. J. C. Chapais, St. Denis-en-bas, P. Q.

Last year (1921), about the month of June, one of my Canadian friends, living now in the United States, wrote to me the following letter:

PLATTSBURG, N.Y., June 11th, 1921.

Dr J.-C. CHAPAIS,
Saint-Denis, P.Q.

Dear Sir,—

The various translations I have made while I was living at the I. A. O. have made me familiar with the names of many noxious and useful insects. How-

ever, I have not been able to find out what is the scientific and English name of the insect called in vernacular French *brûlot*. I would be very much obliged to you if you would be kind enough to give me the scientific and English name of that noxious insect, which I only know by reputation. At L. T. nobody could give me any information concerning this insect.

Your humble servant,

F. B.

On the receipt of the above letter, I made an immediate reply as satisfactory as possible to my correspondent; at the same time I resolved to use the reply for the next annual convention of the Quebec Society for the Protection of Plants as the basis of a paper that might possibly be of some use to those who have suffered from the attacks of the Black Fly, but who did not, however, know its scientific name.

I have written at the beginning of this paper three words; the two first as vernacular terms, and the third, as the scientific designation of the "Brûlôt". To give my correspondent the true signification of the term "Moustique" as he wished me to do, I would use the English word "Gnat", to give that of the term "Brûlot" the English words "Black Flies" and to give that of the term "Simulie", the latin word "Simulia". If one adds as the scientific French appellation of that insect the word, "simulie", we will have the complete nomenclature of all the names used to express the term "Brûlot", this plaguy insect which, during certain seasons, torments so sorely our poor humanity.

Now, to indicate the sources which have helped me to give the nomenclature, I shall give, in order of date, the books where I have found the names.

At page 141 of volume 3rd of the "Naturaliste Canadien", (Provancher), in 1871, I find the following reference to the "Brûlot":

" Dipterous insect, vernacularly named: "Brûlot"; French name "Simule"; " latin name, "Simulia". To that reference in the "Naturaliste" I may add: " vernacular English names: "Biting gnat", "Black Fly".

In the sixth volume of "Le Dictionnaire des Dictionnaires", by l'abbé Paul Guérin, published in 1886, I find, under the head of "Simuli", the following lines: "Genus of dipterous nemocerous insects, family of Bibionidae; Slender " flies, vernacularly called Biting Gnats". Short antennae with eleven " articulations, palpi with four joints, the last being long; no ocelli. The " females only are blood-suckers. Simulia Columbaschesis are found in " Hungary, where it attacks in clouds the herds of oxen (Claus); *simulia* " *pertinax, ornatis*, Southern America. Fossil *simulia* are found in the Weal- " den formation (*Simulia humida*)."

At Page 5641, 2nd column of volume VIIth of "The Century Dictionary and Encyclopedia" published in 1889, we find the following lines relating to the *brûlot*:

" *Simulium*.—An important genus of biting gnats of the family *Simuliidae*. " They are small, hump-backed gnats, of a grey or blackish color, with broad

" pale wings. Many well known species belong to this genus, such as the colum-
" batsch midge of Eastern Europe, the black fly (*S. Molestum*) of the wooded
" regions of the Northern United States and Canada, and the Buffalo and Tur-
" key gnats of the South Western United States. Their bite is very painful
" and they sometimes swarm in such numbers as to become a pest. Their
" larvae and pupae are aquatic, and generally live in shallow swift running
" streams. Also *Simulia.*"

One will note that in 1886 as written above, *Le Dictionnaire des Dictionnaires* of Guérin classifies the Simulium in the Family of the Bibionidae and that in 1889 the Century Dictionary and Encyclopedia classifies it in the Family of the *Simuliidae.*

In the volume "Entomologie et parasitologie agricoles", page 418, a book written in 1917 by Georges Guénaux, Paris, France, under the head"Simulia" will be found the following: "Simulia are very minute biting gnats which flutter
" about in large numbers and of which the females sting men and animals,
" suck their blood and may inoculate them with contagious diseases. Those
" twowinged nemocerous insects are distinguished from mosquitoes, in having
" short and wide wings, wide and flattened legs, thick and short proboscis."

" The ash-colored simulium (*Simulium maculatum*) is three millimeters.
" in length and has its body ash-grey and the abdomen striated with black.
" It flies in spring and, by its stings, maddens the pasturing herds; very often
" it penetrates into the horses' ears and drives them wild. As a result of many
" observations, it is now thought that it sometimes inoculates anthrax."

THE SPRUCE BUDWORM IN QUEBEC PROVINCE

(Extracted from a paper given at the Annual Meeting)

By J. M. Swaine, Chief, Division of Forest Insects, Entomological Branch, Department of Agriculture, Ottawa

About twelve years ago a great outbreak of the spruce or, better, the balsam budworm developed in the vast balsam-spruce forests immediately south of the Height of Land in the Province of Quebec, between Grand Lake Victoria and the country north of Lake St. John. During the next few years this infestation developed southward across the St. Lawrence and eastward over northern Maine and New Brunswick, but missing the end of the Gaspé Peninsula.

The primary budworm outbreak lasted only about three years in each affected district in Quebec Province and then died away leaving in its wake an enormous quantity of dead, dying and weakened balsam and less seriously

injured spruce. In New Brunswick the budworm outbreak apparently lasted longer in some localities and the primary injury was accordingly perhaps more severe. Serious injury to spruce has been confined almost entirely to red spruce which occurs in Southern Quebec and in New Brunswick.

The weakened balsam left by the budworm outbreak was attacked by the Balsam Bark Weevil, *Pissodes dubius* Rand, the Balsam Bark-beetle, *Pityokteines sparsus* Lec., and the Sap Rot Fungus, a species of *Armillaria*. These three destructive agents have been and still are killing great quantities of the remaining unthrifty balsam each year in much of Quebec Province, south of the Height of Land and in New Brunswick, so that, on great areas, in the aggregate thousands of square miles in extent, almost the entire stand of balsam has already been killed or evidently will die within the next few years.

The development of the budworm outbreak towards the west was much less rapid. Although it passed in a few years southwesterly over the DuMoine and Kipewa watershed and finally died away in the hardwood and cultivated areas of the Ottawa Valley the progress directly westward along the Upper Ottawa River north of Lake Expanse and towards Lake Abitibi was apparently exceedingly slow. Our first reports of possible budworm injury in that little known country were received in the fall of 1919. During the summer of 1920 our surveys revealed an enormous budworm outbreak about Long Lake in Western Quebec and extending across the Ontario boundary almost as far as Lake Temagami. Forest sample plots were laid out near Long Lake to aid in detailed studies, and surveys by canoe were undertaken to determine the area of the infestation, the western margin of the outbreak and the direction in which it was spreading most rapidly. The injury we know would affect only the balsam and spruce and would be most severe in stands containing a high percentage of balsam. These stands were located very often in the centre of the blocks into which that part of the country about Lake Temagami is divided by the water courses and the belts of pine with which they are bordered.

It was evident that the only way to obtain rapidly the information we desired was to view the infested country from the air and map the diseased areas as determined from the changed colour of the dead and affected trees. For a few weeks during the last two summers we have carried out a hydroplane survey of the region and have been able to determine the extent of the area affected and, roughly, the western boundary of the outbreak.

Until last summer, in Quebec Province, we were studying the after-affects of a budworm outbreak since the caterpillars had largely disappeared from the Quebec forest, excepting possibly the country north-east of Lake Expanse, before we commenced our investigations. In New Brunswick the primary budworm outbreak continued until last summer and although it has now nearly disappeared in that Province as well, it has left behind it a terrible wreck

of dead and dying balsam and a considerable amount of dead and seriously injured red spruce.

It should be emphasized that although the primary budworm outbreak has been over for some years in probably all of Quebec Province, except the western portion already mentioned, the weakened balsams have continued to die until the present on very large areas, through the action of the beetles and fungi which accompanied and followed the budworm attack, and it is evident now that in the older and more heavily injured stands, growing under less favourable conditions, this injury may be expected to continue until the greater part of the balsam is killed.

In Quebec Province west of the St. Maurice Valley and south of the Height of Land, the balsam of pulpwood size is in large part dead or dying. Throughout a broad belt from Lake Kipewa through Lake DuMoine, Grand Lake Victoria and the Baskatong apparently over 90% of the balsam is dead and fallen. In the area between the St. Maurice Valley and the Saguenay and Lake St. John, the injury has varied in intensity; apparently between 25% and 90% of the balsam is dead, with the average probably 50% of the balsam stand or more. Our reports from the Upper St. Maurice Valley indicated a loss of less than 25%, and we have made no surveys there on that account. We need further information about the loss in that region.

South of the St. Lawrence the loss has been less severe, probably an average of about 25% of the balsam; in places the red spruce has also been severely injured, and in some sections a considerable quantity of spruce has been killed. The Gaspe Peninsula proper has escaped entirely this budworm outbreak. So far as we know the only *active budworm outbreak* in Quebec Province at present is that already mentioned as extending across the interprovincial boundary into Ontario from the country north of Lakes Quinze and Temiskaming. In this country nearly 50% of the balsam is dead now and the rest probably will be dead within the next 5 years.

It is not possible to estimate the quantity of timber killed with any great degree of exactness from the data now available to us. We have no means of knowing how much balsam originally existed on the great area immediately south of the Height of Land upon which the most wholesale injury occurred; but, judging from information we have, and exact estimates which have been made on considerable areas, it would appear that the quantity of balsam which has already died in Quebec or which almost certainly will die within the next few years cannot be much less than one hundred million cords and is probably much greater than this.

Danger from Fires

It is evident that the fire hazard caused by this great quantity of dead and dying trees constitutes a most serious danger. There can be no doubt that fire fighting will be made more difficult for the next few years from this cause, and there was evidence last year that certain large fires spread largely in this dead and dying balsam.

Insects concerned in the Injury

The Spruce or Balsam Budworm, *Harmologa fumiferana Clem.*, is a small brownish caterpillar about three-fourths of an inch in length when full grown. The adult insect is a small, yellowish-brown moth which flies readily, deposits its eggs on the needles of living trees and so distributes the injury. The tiny caterpillars, which have overwintered on the twigs, appear in the early season and attack the opening buds and young foliage. They feed upon balsam, spruces and hemlock; but they affect the greatest injury to balsam and red spruce. When the caterpillars are exceedingly numerous, as in an outbreak, the young foliage on the balsam is largely or completely destroyed and the older needles eaten to a varying degree. Before the dead needles have fallen, the badly infested trees have a reddish, scorched appearance, which is replaced by a greyish color in the later stages of the infestation after the foliage has largely disappeared. The caterpillars are abundant usually for only two or three years, dying out through the combined effects of parasites, predators, lack of food supply and adverse weather conditions. Towards the close of the outbreak redtop balsams, i. e., dead trees with all the remaining foliage turned red, appear, indicating the work of the beetles and fungi which seem invariably to follow a budworm outbreak.

The Balsam Bark-beetle, *Pityokteines sparsus* Lec., is a very small, black beetle, one-eight of an inch in length, found, with its small whitish grubs, cutting tunnels in the inner bark on the surface of the sapwood of weakened and dying balsams. The beetles excavate a minute entrance tunnel through the bark, terminating in a small flattened chamber on the surface of the sapwood, from which radiate several egg-tunnels. These, together with the entrance tunnels, are kept free from boring-dust. The star-shaped tunnels thus formed are occupied by one male and several females, one for each individual egg-tunnel. The eggs are laid in niches along the sides of the latter, and the tiny white larvæ or grubs excavate slender larval mines which are packed behind the larvæ with dustlike excrement. The larvæ pupate in the ends of their mines and eventually cut their way through the bark to freedom to attack fresh balsam slash, and weakened or recently killed trees.

This species breeds abundantly in balsam slash and in dying and weakened balsams but rarely, if ever, attacks healthy trees.

The Balsam Bark Weevil, *Pissodes dubius* Rand., is a greyish snout beetle, with whitish markings, about one-quarter of an inch in length. The beetles appear in the spring and deposit eggs in groups of punctures in the bark of the trunk of standing balsams. The resin which exudes from the punctures hardens and forms whitish patches on the bark which are more or less characteristic of the injury. The larvæ which hatch from the eggs excavate very long mines in the inner bark, from six to twelve inches in length, radiating from the group of egg punctures, and left filled behind the larvæ with reddish excrement. The larvæ are about one-quarter of an inch in length when mature. They pupate in the ends of the tunnels and eventually emerge through individual exit tunnels cut through the overlying bark, leaving a round exit-hole.

This species does not oviposit in dry trees or old slash. It attacks weakened balsams and may affect trees showing little evidence of being unthrifty. The work of this species is easily distinguished from that of the Balsam Bark-beetle through the absence of egg-tunnels, the larger grubs, and the longer, larger mines, radiating from the egg-punctures.

Control

When we commenced our study of this problem the primary budworm outbreak was over, in the greater part of Quebec Province, and the secondary bark-boring beetles were attacking the weakened and dying trees. There was, therefore, no possibility of controlling the budworm; its work was already done. It should be clearly understood that the problem we have now to deal with in Quebec, except for the extreme western section, is not at present the control of a budworm outbreak, but rather the control of the beetles which followed the budworm, the salvage of the standing and dying and weakened balsam and the development of a system of forest management, supplemented by possible direct control, which will prevent another calamity from the same cause in the years to come.

Our aim has been to obtain all information available regarding the injury, the factors which affected its rise and fall and to determine some methods of avoiding the greatest loss from the next budworm attack. We may not have another outbreak for a generation, or more, but when it does come these conditions will probably obtain; the percentage of balsam in Quebec forests will be very much higher than it was 10 years ago and our pulp industry will be dependent very largely upon balsam for its wood supply. This high percentage of balsam will invite a very heavy injury; but if we can manage to have a healthy stand of growing balsam without large areas of mature and overmature timber or if the percentage of spruce in the coming stands can be increased, the effects of an outbreak will probably be much less destructive.

Utilization of dead and mature balsam

It is evident that the dead, dying and mature balsam should be utilized wherever and as rapidly as this is commercially feasible. As a matter of economy, as much as possible of the standing dead material should be utilized. The balsam and spruce are usually perforated by the large tunnels of wood borers within two years subsequent to their death, and the action of fungi destroys the quality of the wood very rapidly, more quickly in the balsam than in the spruce.

Control of beetles

As already stated, although the budworm itself has disappeared from the greater part of the province, the balsams are still dying rapidly in many places through attack by the secondary barkboring beetles and the sap-rot fungus. These attack the bark of the trunk and kill the trees in one year, causing them to turn red. The control of these beetles should be feasible under some circumstances. When these red-top trees are becoming abundant and a valuable stand of balsam is apparently threatened, it will evidently be profitable to cut out the infested trees during winter and put them in water in early spring and thereby prevent the spread of the injury. This is being carried out on a considerable scale by one Quebec company this winter.

One of the beetles concerned, the Balsam Bark-beetle, breeds in slash and burning the slash will destroy, in addition, other boring insects and heart rot fungi which are injurious in the forests. This is an additional reason for urging that slash burning must form a part of any permanent forest policy.

Cutting out the red tops will be profitable only in special cases. Slash-burning is only a help in this matter of control. In badly injured areas where balsams are still dying rapidly, the policy should be to concentrate on the balsam cutting in so far as is feasible, so as to salvage as much of it as possible and also thereby leave the future stand in a young and thrifty condition.

Direct Control Methods

Direct control for an active outbreak of this nature spreading over hundreds or thousands of square miles is almost inconceivable. This could be accomplished only by destroying most of the caterpillars in the badly infested sections through fire, through extensive cuttings of infested trees, or by means of poisons. Of these, the distribution of poison dust by an air machine flying low over the trees is the only plan that seems theoretically feasible, and it is hardly so at the present time. A somewhat similar experiment was carried out in the Eastern United States this summer in which a block of 5,000 catalpa trees affected by caterpillars was treated with poison dust distributed from an aeroplane, and it is reported, with complete success. Before the next bud-

worm outbreak arrives, we hope to have an intelligence system in operation through which the insect activities in all parts of the forest will be reported to the entomologists; and, when it is found that a fresh budworm outbreak is threatening, it may possibly be feasible, using the planes and poisons that will be in use by that time, to destroy the carterpillars in sufficient numbers to check an outbreak effectively. At all events, it will certainly be tried by our successors. The present primary outbreak in the Temiskaming is too widespread to be dealt with successfully by our present appliances; but we shall at least test the effectiveness of the method if a suitable opportunity offers.

It is becoming more evident to us, as we study these problems, that our chief hope for a healthy, thrifty forest in Eastern Canada in the future must depend upon the development of policies and plans for forest management.

Summary of Suggestions for Control

Utilization of balsam as soon as it reaches maturity under its local condition, in the hope that a healthy growing stand will not encourage a budworm outbreak.

Utilization of dying and dead balsam for salvage and the removal of fire hazard. It is important to salvage as much of the dead and dying timber as possible before it becomes an entire loss, a matter of two years usually for both balsam and spruce through the action of wood borers and fungi, and it is also of the greatest importance to reduce as much as possible of the combustible material.

Cutting out red top balsams during winter combined with slash burning to control balsam weevil and balsam bark-beetles.

Future slash burning to prevent development of the Balsam Bark Beetle.

Application of poisons by hydroplane in initial stages of future budworm outbreaks. Some such method of direct control may be feasible in the future although the difficulties seem at present almost insurmountable.

Forest management to encourage types of forest least susceptible to budworm injury, the utilization of spruce and balsam before overmaturity, better adaptation of type to soil, and the utilization of hardwoods so that a budworm immune mixed hardwood-coniferous forest may be commercially profitable. This important feature of the problem is discussed in detail in Craighead's paper on "Possibilities of Preventing Losses from the Spruce Budworm in the Proceedings of the Quebec Forest Protective Conference for 1922".

A Forest Insect Intelligence System

It is hoped to establish throughout our eastern forests, an intelligence system, through co-operation between foresters, lumbermen, all travellers of the forests, and the forest entomologists whereby the entomologists will

receive regularly from all parts of our forest area reliable reports upon all important insect injuries. With this system in operation it will be possible to discover insect outbreaks in their initial stages, to make an expert examination and to put in effect whatever direct control measures may at that time have been devised.

The perfection of this intelligence system will prove without question a most effective aid in avoiding and controlling serious forest insect injuries.

CHEMICAL WOOD PULP IS ATTACKED BY MOLDS

By R. J. Blair, Pathologist, Forest Products Laboratories of Canada

Wood pulp manufacture falls into two main divisions known as the mechanical and chemical processes. Mechanical pulp often spoken of as groundwood is made in a machine where sticks of wood are held against a revolving grindstone. For chemical pulp the wood is first cut into chips which are cooked in large digestors at high temperatures under pressure. For cooking the chips the digester is filled with a chemical solution which dissolves the lignin from the wood leaving the fibre behind in a more or less impure form of cellulose. According to the chemical used for the cooking liquor, three different kinds of pulp are made known as sulphite, sulphate and soda. Each of these kinds of pulp may be subsequently bleached.

An idea of the importance of the industry to Canada may be obtained from the following figures. In 1920, 2,777,422 cords of pulpwood were manufactured into pulp by the various processes. The wood used and pulp produced are as follows:

Kind of Pulp	*Cords of Wood*	*Tons of Pulp*
Groundwood	1,080,618	1,090,114
Sulphite	1,354,023	675,733
Sulphate	330,907	188,487
Soda	11,874	5,768

Part of this output is made into paper immediately but a considerable portion is either exported or stored in Canada before it can be used up. For various reasons several months often elapse from the time the pulp is manufactured until it is made into paper and it is during this interval that losses due to molding occur.

Work upon the molds affecting groundwood pulp has been carried on by the Bureau of Plant Industry of the United States Department of Agriculture,

but so far as is known no reference has been made anywhere to attack of chemical wood-pulps by molds. The purpose of this short article is to state that material has been submitted to the Forest Products Laboratories of Canada showing a molded condition in sulphate and soda pulps and sulphite both bleached and unbleached.

The first appearance of moldiness occurs as small discoloured spots of which a number are often found in a single sheet. The discoloration is usually dark grey, black or brown but it may also be greenish, yellowish or a deep pink. At the outset the actual harm done to the pulp may be very slight, consisting

Fig. 1.—Fibres taken from mold spot in Sulphite pulp. x 300

principally in a discoloration limited to small areas. If the action is not checked the discoloration spreads until the pulp finally becomes worthless. The early discoloration may lower the price of the pulp out of all proportion to the actual damage caused as the small amount of material containing the coloured matter is so broken up in the beater that the colour of the paper made from it is not appreciably changed.

The accompanying photomicrographs show conditions found in the different kinds of pulp studied.

Fig. 2.—Fibres taken from mold spot in ? Triplate pulp. x 300.

Fig. 3.—Fibres taken from mold spot in Soda pulp. x 300.

A FEW POINTS OF INTEREST IN CONNECTION WITH FOREST ENTOMOLOGY

By M. B. Dunn, Assistant Entomologist, Entomological Branch, Ottawa

A great many attempts have been made to estimate the actual damage done to the forests of Eastern Canada during the last few years by the spruce bud worm. All of these, it matters not how carefully they may have been carried out, must necessarily be but rough approximations, but they at least serve to convey some idea of the terrific havoc for which this insect is responsible.

Last year in New Brunswick, we ran a number of test strips, 30 x 100 feet. These strips were located in varying types and sections of the country, having only this in common that they all had at least a little of the largest timber taken out. All standing trees whose appearance denoted that their death was directly attributable to the bud worm were counted and the diameter of each at four and one-half feet from the ground was taken. With volume tables kindly supplied by Mr. Wm. Robertson, of the Dominion Forestry Branch, the loss in merchantable cubic feet for each strip was estimated and an average made for the various strips. The average proved to be 118. merchantable cubic feet for balsam and 11.7 for spruce. Carrying these figures a little further, and estimating the number of strips per square mile, we find the loss in the province of New Brunswick, which has a main forest block of approximately 100 miles square, to be in the neighborhood of 10,900,000,000 merchantable cubic feet for balsam and 1,087,000,000 for spruce. These figures seem appalling. They appeared incredible at first, even to the men who did the work, and we went over our calculations several times in the hope that there was a mistake somewhere, but none could be found.

As a further illustration of just how much lumber such a pile would be, it can be estimated that if one had such an amount in manufactured lumber at his command, he could begin to build cosy little seven roomed houses at Halifax and, leaving only twenty feet between each house, he cold build four rows of such houses clear across Canada to Vancouver.

Now this loss was all in the Province of New Brunswick in a comparatively small area. When one remembers how many times larger is the forest area of Quebec and Ontario, and also that some of it at least is virgin territory for which these figures would be too small, one begins to get some vague idea of the damage which has been done. Added to this certain loss there is the almost certain one due to forest fires which, owing to the dry condition of the timber, can now hardly be prevented from raging over a large part of this territory.

Another interesting phase of our work is that in connection with sample plots. In co-operation with the Conservation Commission and several lumber companies, we have established at various points throughout the forests of Eastern Canada, a total of thirty-two sample plots. We have under observation on these plots slightly over twelve thousand trees, mostly spruce, balsam and pine.

The method of establishing these plots is briefly as follows. A suitable location is chosen and a rough line is run around a block of one or two acres. The trees on this block are then consecutively numbered, either with white paint or by means of aluminum tags, fastened to the trees with copper wire or copper or brass nails. The paint method is probably much the better since it is considerably cheaper and it has this advantage, that individual trees are very much easier of subsequent location.

Sample plots are proving of invaluable aid to forest insect problems. Without exact records of individual trees continued over a number of years, it is practically impossible to obtain satisfactory data on certain phases of the work. On the sample plots, however, where the numbering of the trees makes their annual location easy, entomological investigations can be conducted with much greater efficiency than is otherwise possible. The sample plot is not intended as a direct control measure or anything of that sort, of course. Its value lies entirely in the field of experimental investigation, and it offers a sure and efficient method of learning everything possible about the life history and habits of the various insects upon which we have to make war. When we get all these facts within our grasp, then, and only then, will we be able to arrive at methods of control which will effectively check in their incipiency any dangerous forest insect outbreaks of the future.

EXPERIMENTS ON THE CONTROL OF THE ONION MAGGOT, 1921

By W. Lochhead and W. J. Tawse, Macdonald College

In collaboration with the Dominion Entomological Branch, the Entomological and Horticultural Departments of Macdonald College carried out experiments in the spring of 1921 against the onion maggot. For several years this insect had caused severe losses to the onion crop in the truck gardens in and about Montreal, and the owners gladly placed their fields at the disposal of these Departments for testing out any method which gave promise of relief.

The experiments were conducted on six farms, viz., in Rosemount on the farms of J. and M. McEvoy, in Outremont on the farm of Paul Wattiez, in Cote des Neiges on the farms of A. Savoie and A. Deguire, and at Macdonald College.

The Arsenic Bait.—The method of control selected was the application of poisoned bait of sodium arsenite and molasses, prepared as follows:—¼oz. sodium arsenite was dissolved in one gallon of boiling water, and 1 pint of cheap molasses added. This bait was applied in two ways:—(1) in shallow pans, placed at regular intervals throughout the field, and (2) as a spray.

The pans used were round shallow tins, about 1½ inches deep and 6 inches wide, costing 7½c each.

Into each pan a small lot of excelsior was placed and the sodium arsenite mixture poured upon it, with the idea that the flies would the more readily get access to the mixture. About 20 pans were used per acre, and they were refilled every week for four weeks.

When the sodium arsenite mixture was applied as a spray, an ordinary watering can with a small nose was used. Acre plots were treated quickly when the operator began at one end of the plot and walked diagonally across the crop back and forward in a V-shaped manner, the strips being about 15 or 20 feet apart at the wide end.

The first application was made when the plants were three or four inches high, and four or five further applications made about a week apart. Bright calm days should be chosen for such work.

Life-history of the Onion Maggot Fly.—The adult flies, which are about ¼ inch long and bristly, begin to appear about the middle of May, and about *ten days afterwards the females begin to lay their eggs* on the leaves. These are cylindrical, white and distinctly ridged. The eggs hatch in three to five days, and the maggots are white, cylindrical and less than half an inch long when full grown in 2 to 5 weeks. They work their way down within the sheath of the leaves to the forming bulbs in which they feed.

When the maggots are full grown they form oval, brown puparia, either in the outer layers of the bulb or in the soil, about 2 to 5 inches below the surface. In about two weeks flies emerge from the puparia. There are probably three broods a year, and they pass the winter as *puparia in the soil.*

The control method is based on the fact that the flies do not lay their eggs until about ten days after emergence from the ground, and that they are fond of sweet substances.

Following are the results and summaries of the experiments:—

MONTREAL ONION MAGGOT CONTROL WORK, MONTREAL.

Location	Name	No. of Acres	No. of Pans	% control Treated	% attacked untreated
Rosemount.....	J. McEvoy...	2	40	98%	
		1½	30	92-95%	
		4	Spray.....	80-85%	
	M. McEvoy..	10	200	.....	20% before pans were put out.
Outremont.....	Paul Wattiez.	1	20	90-92%	
		1	Check.....	.....	15-20%.
Cote des Neiges	A. Savoie....	2	40	98% or 420 bus.	
		2	Check.....	.....	6% (393 bus. yield.)
Cote des Neiges	A. Deguire...	2½	50	96%	
		2½	Check.....	.....	10% attacked.

ONION MAGGOT CONTROL

On the farm of Mr. Jack McEvoy, Rosemount, Montreal

1st plot next the highway above the storage.
2 acres, requiring 40 pans.
2nd plot below far storage in the centre of the farm.
1½ acre requiring 30 pans.
3rd plot just beolw the first storage house was sprayed with the watering can diagonal bait.
Pans set out and filled May 27—28th.
2nd. Refilled May 31—Weather hot and dry.
3rd. " June 6—Owner refilled on the 2nd and again on the 4th on account of heat and heavy rain on June 3rd.
4th. " " 10—.
5th. " " 15.
Note:—The spraying was carried out each time the pans were filled.

Summary of Observations

I.—First, the two acre plot above the storage was 98% free of maggot injury. Numerous counts showed from 12 to 20 dead flies in and around the pans.

II.—Secondly, the one and a half acre plot below the far storage showed very little injury with the exception of the end near the manure pile next to the storage. This end was attacked before we set out the pans as the heating manure provided seemingly an ideal refuge against the cold winds and nights. Observations during the fly period and latter throughout the summer did not change the proportion affected by the maggot, which was placed at 5–8%.

III.—The third plot of four acres on which was tried the diagonal watering can spray was situated just back of the first storage house. The results here were not to be compared with the pan control as the spray seemed to dry too quickly and as a result there were 20% or more of the onions attacked by the maggot. This field was also attacked by onion smut (*Urocystis Cepulae*) which further reduced the yield.

IV.—The fourth plot of Mr. M. McEvoy's consisting of ten acres was left for a check as he had not previously been bothered with this pest. However, on June 10th, the field was so badly attacked that Mr. McEvoy secured 200 pans and treated the whole piece, which quickly controlled the flies, as we counted in and around the pans twelve to twenty eight. Beyond patches here and there this field finally turned off a fair crop of onions for the past season of good average size.

These growers were very pleased with the results obtained from the pans as they were easily and quickly refilled and did not hinder cultivation. They did not, however, like the diagonal spray as it required twice the amount of liquid and was not nearly so easy to apply. It required more material and time to apply while the damage to the standing crop was only kept down by carefully watching the rows.

The four-acre plot at Mr. J. McEvoy's, where the diagonal spray was used.

A two acre plot in front of storage plant at Mr.J. M Evoy's—98% stand.

The ten-acre plot of Mr. M. McEvoy showing Maggot damage very heavy in spots.

ONION MAGGOT CONTROL WORK

On the farm of Mr. A. Savoie, Cote-des-Neiges, Rd.

Plot of two acres of the four acre field. Required forty pans.
Set the pans out on May 26th, 1921.
Refilled the pans —June 1st.
" " " June 7th.
" " " June 14th.
" " " June 18th.

Mr. Savoie weighed the onions :
1 acre treated giving 420 bus.
1 acre untreated gave 393 bus.
Estimated control 98%. Attacked 6%.

ONION MAGGOT CONTROL WORK

On the farm of Mr. A. Deguire, Cote-des-Neiges, Rd.

Plot selected consisted of two and a half acres (2½) requiring fifty pans.

These pans were set out and refilled on the same dates as Mr. Savoie's. We were unable to get the final yields as in the owner's absence the hired help lost the count and before this was discovered the onions were all in several storages. The observations noted throughout the season brought out the fact that this pest is not nearly so numerous as in the Rosemount area. The untreated plot was thinner in patches, but when pulled averaged larger in size. The treated was estimated at 96% control while the loss on the untreated was not more than 10%.

ONION MAGGOT CONTROL

On the farm of Mr. P. Wattiez, Outremont, Montreal.

Plot of 2 acres divided in half. The lower end treated with twenty pans and the upper end left as a check.
The pans were set out on May 26th.
Refilled June 2nd, 6th, 14th.

On June 18th these plots were examined and found in the case of the treated plot to be only lightly affected estimated at 8-10%. The untreated plot was much worse, showing many blanks and wilted spots estimated as 15-20%.

The whole crop was sold as bunch onions as soon as the bulbs were large enough for kitchen purposes.

ONION MAGGOT CONTROL

In the Horticultural Gardens of Macdonald College

I.—Plot consisting of one-third of an acre.
Near old onion ground requiring 7 pans. block 1.
II.—Plot of one third of an acre in block II as a check two hundred feet away.
III.—Plot of one third of an acre in block IV seven hundred feet from the check for the diagonal spray.

Pans set out May 26th. Refilled 31st, June 6th, 14th. The first block under the pan system was badly attacked as it was close to the old onion ground of previous years. We estimated the damage at 15—20% on the one end. The plot yielded 78 bushels.

The second plot used as a check consisting of one-third of an acre was attacked very lightly in spots. The damage was estimated at 5%. The total yield could not be secured as 1-6 of the block was sold as bunch onions in August. The other sixth yielded 45 bushels.

The third plot for spraying was practically free of maggot as nearby were planted two rows of seed onions which attracted the flies. This plot yielded 96 bushels.

COST OF ONION MAGGOT CONTROL

Cost of Pans, 20 per acre, at 7½c	**$ 1.50**
Sodium Arsenite, 2½ oz at 60c lb	**.10**
Molasses, 1¼ gallon at $1.35	**1.69**
Cost of arranging and putting out pans, 2 hrs at 30c	**.60**
Cost of refilling pans 4 times, 4 hrs. at 30c	**1 20**
Total cost of treating per acre	**$ 5.09**

THE DISTRIBUTION OF THE EUROPEAN CORN BORER IN CANADA AND THE UNITED STATES

By W. N. Keenan, Assistant Entomologist, Division of Foreign Pests Suppression, Entomological Branch, Department of Agriculture, Ottawa.

Outbreaks of foreign insects usually do not occur until several years after the species have been introduced into new environments. This rule seems to have held in the case of the European Corn Borer, as the insect was not discovered in the United States until 1917 (in the Boston vicinity), and its establishment in Canada was not recognized until 1920, whereas there is almost conclusive evidence that it was first introduced in shipments of broom corn into both countries about the years 1909 or 1910.

Area infested in the United States

An investiga ion of he original discovery in M ssachusetts, which was carried on in 1917 and 1918, showed that the pest was present in thirty two townships in the counties of Essex, Middlesex, Suffolk and Norfolk in Massachusetts. Early in 1919 a new area was discovered in eastern New York State in the vicinity of Albany and also late in the same year in western New York State. Collections were also taken in New Hampshire and Pennsylvania during the same season and at the end of 1919 he infested area comprised 111 townships in Massachusetts in the counties of Barnstable, Essex, Middlesex, Norfolk, Plymouth and Suffolk; 3 townships in Rockingham County in New Hampshire; 26 townships in the counties of Albany, Fulton, Montgomery, Rensselaer, Saratoga, Schenectady and Schoharie in New York State (*eastern*); 13 townships in Cattaragus, Chautauqua and Erie counties in New York State (*western*) and one township in Erie County, Pennsylvania.

As a result of further scouting carried on in the United States during 1920, 15 additional townships in Massachusetts, in the counties of Plymouth, Norfolk, Middlesex and Bristol were added to the quarantined areas, as well as 5 townships in Rockingham County, New Hampshire; 12 townships in New York State (eastern) in the counties previously mentioned; and 14 townships in Chautauqua, Niagara and Erie Counties in New York State (western).

In 1921 the spread of the insect seems to have been the greatest, as specimens were collected in many new townships, some distance from the old points, and at the present time the area under quarantine for the corn borer in the United states comprises the following:

Massachusetts

One hundred and forty-three townships in Barnstable, Bristol, Essex, Middlesex, Norfolk, Plymouth and Suffolk counties.

New Hampshire

Twelve townships in Rockingham county.

New York (eastern)

Sixty-nine townships in Albany, Fulton, Hamilton, Montgomery, Rene. selaer, Saratoga, Schenectady, Schoharie, Washington and Warren counties-

New York (western)

Forty-six townships in Cattaraugus, Chautauqua, Erie and Niagara counties.

Pennsylvania

Twelve townships in Erie county.

Ohio

Forty-two townships in Ashtabula, Cuyahoga, Erie, Lake, Lorain, Lucas and Ottawa counties.

Michigan

Three townships in Monroe county.

The 1921 results represent an increase of 127 townships in the infested area, making a total of 327 townships under quarantine at the present time or approximately 9253 square miles.

Area infested in Canada

As previously stated, the European Corn Borer was not discovered in Canada until 1920. In that year two separate infestations were found in Ontario. The first and less severe of the two comprised 3 townships in Welland County and two in Haldimand County, bordering Lake Erie. The second infestation contered about the St. Thomas district and included all of Elgin County, the majority of Middlesex County; 6 townships in Oxford County, 4 townships in Kent County, and one in Huron County; a total of 35 townships and covering an area of 2780 square miles.

In 1921, in Ontario, we also experienced a much greater spread of the insect than was expected. A total of 65 additional townships were found infested and it was considered advisable to add seven others to the quarantine on account of their respective situations. At the present time there are 107 townships under quarantine in southern Ontario, covering a total of 8214 square miles and including the following areas; *Welland*, *Haldimand*, *Brant*. *Norfolk*, *Oxford*, *Waterloo*, *Middlesex*, and *Elgin* counties; the townships of Clinton, Cainsboro, Grantham, Louth, and Niagara in *Lincoln* county; the township of Ancaster in *Wentworth* county; *Perth* county with the exception of Elma and Wallace townships; the townships of Goderich, Stanley, Tuckersmith, Hay and Stephen in *Huron* county; the townships of Warwick, Brooke and Euphemia in *Lambton* county; the townships of Orford, Howard, Harwick, Raleigh, Tilbury East, Romney, Zone, Gore of Gamden and Camden in *Kent* county; the townships of Mersea, Gosfield South and Pelee Island in *Essex* county, and the township of Pickering in *Ontario* county.

As will be noted there was enormous spread of the insect in Ontario in 1921 but as all conditions were unusually favorable it is hoped that a much less area will be involved in the succeeding season's spread. The majority of the increased distribution is apparently natural but the isolated collection in Pickering and the Essex and southern Kent County infestations indicate artificial transportation of the insect.

An examination of the areas infested by the corn borer in the United States and Canada and the conditions accompanying each area suggests at least four centres of infestation: Massachusetts, New York (eastern), New York (western) and the St Thomas district in Ontario. The 1921 results would indicate that lake shore conditions are very favorable for the spread of the insect, as collections were made in practically all townships surrounding Lake Erie. This may be due to any one of several factors including water currents into which infested corn refuse has found its way, wind currents with adults in flight, and shipping transportation

The importance of the European Corn Borer as a pest is recognized by all who have seen the results of its work Every effort, both in the United States

Map showing areas infested in black.

and in Canada, is being made to reduce its spread to the minimum and to devise the best methods for treating infested areas. Quarantines have been placed on the infested townships in both countries which prevent the removal to outside areas of products liable to harbor the borer... Control measures of importance have been recommended by the Dominion and Provincial Departments of Agriculture in circulars distributed amongst the growers in the infested districts in Ontario. These control measures include planting as late as is safe, early and low cutting of corn, ensiling the crop, early and careful ploughing of stubble fields followed by rolling and the proper disposal of all refuse corn stalks, weeds, etc., about the premises before the first of June.

Investigations will be continued in Ontario again this season and an effort will be made to test the value of the above control measures by an organized campaign in a definite area of the most heavily infested district.

The gradual spread of the corn borer is naturally to be expected but the value of the quarantine in preventing the wholesale shipment of infested pro-

ducts to any and all parts not already affected, is readily understood and in carrying out the regulations several infringements have already been discovered.

The confinement of the insect to the minimum area is not only important in regard to crop losses caused by it, but also in reducing the difficulty in the adoption of control measures. The only sections experiencing extreme damages thus far in Ontario have been confined to Elgin and Middlesex counties, more particularly Elgin county. In view of this a second quarantine has been placed on these two counties, which prevents the movement of products affected by the quarantine to points outside the two counties.

PLANT DISEASES OF 1921 IN QUEBEC

By B. T. Dickson, Professor of Botany, Macdonald College

The year 1921 in Quebec was typically a year of Fusarium root-rots and of mosaics.

Field peas were severely attacked by *F. lathyri*, beans by *F. martii phaseoli* and asters by *F. orthoceras*. It was difficult to grow sweet peas in any light soil owing to the heavy infection by *F. lathyri* in July and August.

Fig. 1.—Plant diseases of 1921 Mosaic of Red Clover (T. pratense)

Fig. 2.—*Vermicularia varians* on dextrose agar, Setae well-developed

Fig. 3. — Plant diseases of 1921 *sclerotia* of *Vermicularia* on stem and inside stem

Fig. 4.— Leaf spot of rhubarb caused by *Phyllosticta straminella*. Note pycnidia at A.

Fig. 5.—Sclerotia of *Colletotrichum crumpens* grown on dextrose

Fig. 6.—Sclerotinia disease of sunflower. Fully developed sclerotia at A and young sclerotia at B.

Fig. 7.—Sclerotinia disease of sunflower. Note sclerotia inside stem at A, the mycelium at B, and the effect on the tissues at C.

Mosaic was prevalent on clovers (red, crimson, alsike, white, and trefoil), on sweet clovers (white and yellow), on beans (kidney, both dwarf and pole varieties, and Windsor or broad beans), on raspberry, on tomato and tobacco, and on sweet pea. In addition the field pea (*Pisum sativum*) was determined as a new host. Hundreds of tomato fruits showed characteritic mosaic mottling and red blossoms of sweet peas exhibited a marked and rather beautiful mottling. As a result of systematic efforts on the part of Dominion and Provincial authorities mosaic of potato was not severe.

Fig. 8.—Bladderplums caused by *Exoasus pruni*. Only four plums are uninfected.

Leaf hopper burn of potato was serious in certain areas and a disease, new to this continent ("Dartrose" or "Black dot disease") was discovered by the writer. This is apparently not serious and is caused by *Vermicularia varians* Ducomet. It was reported and described by Ducomet from France in 1908 and

later reported from Victoria, Australia, by McAlpine and from South Africa by Doidge.

Late blight was not noticed until about September 1st and during the warm wet period following it became pronounced. In storage during the middle and late winter, extensive rotting occurred, doubtless due to *Phytophthora infestans* in part, with *Fusarium spp.* contributing largely as a result of invasion through lesions and injuries in immature skins.

Onion smut (*Urocystis cepulæ*) was serious in one or two market gardens in the vicinity of Montreal.

Beans were affected by anthracnose but the most serious loss was caused by blight (*Ps. phaseoli*).

Sclerotinia disease of sunflower has been present during the last two seasons to a slight extent, but during 1921 it was present up to 2% in one of the experimental plots at the College.

Soft rot of cabbage, cauliflower and turnip was found in localized areas. Rhizome rot of Iris, caused by *B. carotovorus*, was present in practically every Iris bed on the Island of Montreal, and at Macdonald College it has been the major cause in the loss of some one hundred and twenty varieties during the last five years.

Rhubarb in gardens was found to be affected by *Phyllosticta straminella* causing leaf spot and *Collectotrichum erumpens* causing principally a leaf stalk rot. Both these diseases are new in Quebec and were recently described by F. L. Stevens (Bull. 213, Illinois Agricultural Experiment Station).

Peonies were slightly affected by Botrytis blight and seriously by a leaf spot disease which is being studied by Mr. Coulson of this Department.

Of the fruit diseases apple scab was well controlled, black rot of apple was present in many orchards, silver leaf was present but not serious, brown rot of plums (*S. cinerea*) and bladder plums (*E. pruni*) were fairly common, and raspberry curl was severe generally.

Unfortunately it was impossible to make a detailed survey in order to determine the actual percentages of infection in the various crops but these notes indicate the chief diseases present.

AN ALTERNARIA DISEASE OF POLYPODIUM

By T. G. Major, B.S.A., M.Sc.

During the past winter the attention of the writer was drawn to a spot disease occurring on a fern (*Polypodium sp.*) in the experimental greenhouse at Macdonald College. The disease appeared to be spreading very rapidly and was ruining the plant from the decorative point of view. Since it was the only specimen of its kind in the greenhouse it was determined to carry out some experiments to ascertain the cause of the disease. The results of these experiments show that the causal organism is an *Alternaria*. The writer has not been able to find any reference in the literature to an Alternaria disease of Polypodium.

An Alternaria disease of Polypodium.

Symptoms

The lesions occur mainly on the fronds but some may also be found on the stems. They are of the typical *Alternaria* kind, brown in colour, circular to elliptic, of various sizes, occurring singly or in groups, concentrically zonate with age, irregularly scattered over the surfaces of the fronds, but mostly at the edges and tips. This last condition is probably due to the fact that the water tends to gather at the edges and serves as a favourable medium for the germination of the spores of the fungus.

Causal organism

The pathogen is a member of the Adelomycetes (1), order Moniliales, family Dematiaceæ, genus Alternaria. The writer has been unable to identify it with any species of this genus previously described and suggests tentatively the name *Alternaria polypodii* n. sp. with the following characters:—

Mycelium hyaline to light brown; conidiophores erect, simple or sparsely branched, septate, usually darker than the vegetative hyphæ, 24.5-42.5 x 1.7-4.4 u; conidia clavate, usually broadest in the middle, septate mostly transversely but also longitudinally, muriform, with long hyaline beak at the apex, catenulate, olive to dark brown in colour, measuring 24.5-70.0 x 10.5-19.25 u, (40.3 x 13.6 u).

Variation in spore sizes.—The nature of the substratum has considerable influence on spore size. To make allowance for this factor the organism was grown on iris leaf juice agar, oatmeal agar, and Richard's solution agar and careful measurements made of the spores produced on these media in addition to those occurring on the host plan. The range and average on each medium follow:

Lesions on Polypodium		31.5–70.0x10.5–19.25u	(47.6x14.0 u)
Iris leaf juice agar	PH 5.9	24.5–52.5x10.5–15.75 u	(36.7x13.1 u)
Oatmeal agar	PH 6.5	28.0–52.5x10.5–17.5 u	(37.4x13.9 u)
Richard's solution agar	PH 5.2	31.5–52.5x10.5–17.5 u	(39.5x14.3 u)

The iris leaf juice agar is an infusion of iris leaves in distilled water with 2% dextrose and 2% agar. The oatmeal agar contains 50 grams oatmeal, 20 grams agar, and 1000 cc. of distilled water The last medium was made by adding 2% agar to Richard's solution.

Pathogenicity

Isolations were made by sterilizing the outer surfaces of small bits of diseased tissue in mercuric chloride (1:1000), washing in sterile water and planting them in agar. In most cases the Alternaria described above was the only organism which developed. The hyphæ could be seen plainly growing out from the edges of the diseased tissue. Since this fact seemed to point to the pathogenicity of the organism, a number of inoculation experiments were carried out on the host plant.

A suspension of spores was sprayed, by means of an atomizer, on the fronds of the fern. Only a few minute lesions resulted and no Alternaria could be isolated from them. Believing that the lack of infection was due to unfavourable moisture conditions, measures were taken to control this factor. A young healthy frond was washed in mercuric chloride and sterile water and then enclosed

in a sterile glass chimney. A wad of absorbent cotton was soaked in sterile water insert ed in the outer end which was then closed with a plug of drycotton. A spore suspension was then, as before, sprayed on the frond, and the inner end of the chimney closed with absorbent cotton. Two days after inoculation numerous lesions appeared over the surface of the frond. These developed into typical spots identical with those originally found. Small bits of the diseased tissue thus produced were externally sterilized and planted in agar. The organism which developed from these lesions was found to be identical with the one first isolated, thereby completing Koch's rules of proof.

Summary

1. A hitherto unreported disease of *Polypodium sp.* has been found in the experimental greenhouse at Macdonald College.

2. It is characterized by the occurrence of brown, concentrically zoned spots on the fronds and stems.

3. The pathogen is a member of the Adelomycetes and has been tentatively named *Alternaria polypodii* n sp..

4. The conidia measure 24.5–70.0 x 10.5–19.25 u, averaging 40.3x13.6 u.

5. There is a considerable variation in spore size on different media.

6. The disease has been experimentally produced by spraying a spore suspension of *A. polypodii* on healthy, sterilized fronds.

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Illustrations

Fig. 1.—Growth on steamed rice—29 days.—PH. 6.4.
Fig. 2.—Growth on potato agar—22 days—PH. 6.8.
Fig. 3.—Habit sketch, (reduced one half).
Fig. 4.—Growth on 2% dextrose agar—79 days—PH 6.7.
Fig. 5.—Growth on Richard's solution agar—17 days—PH. 5.2.
Fig. 6.—Growth on iris leaf juice agar—10 days—PH 5.9.
Fig. 7.—Growth on iris leaf juice agar—17 days PH 5.9.
Temperature in all cases 20°C. Magnification about 330 x.

HOW WE MAY INCREASE THE EFFECTIVENESS OF ECONOMIC ENTOMOLOGY

By Geo. A. Dean, Kansas State Agricultural College

(A SYNOPSIS)

Note.—This paper was read in full at the meeting by Rev. Father Leopold, but a synopsis is given here as the paper is printed in the Journal of Economic Entomology. Feb. 1922, pp. 44-53.

As the problems of the entomologist have not only multiplied but have become more complicated during the last few years, it is very evident that

means must be taken to meet the demands of these problems. These are: "(1) fundamental training for research must be insisted upon and its importance emphasized; (2) an agreement as to which are the most fundamental problems of research and which are the most promising methods of attack must be reached, so that the available resources may be concentrated; (3) a workable plan for co-operation among entomologists, with other scientists, with public and private agencies, and with the general public must be developed and supported."

It is obvious that the economic entomologist should have a broad and fundamental training along all biological lines and many other sciences for the science of Economic Entomology is intimately related to many others. Moreover, there is a need for more organization, co-operation and co-ordination, with regard to the whole question of research; but perhaps the greatest need at the present time is a workable plan of co-operation, which should include: (a) Co-operation among entomologists themselves so that workers interested in similar problems may meet together in conference frequently and "pool resources"; (b) Co-operation between entomologists and other scientists in order that inter-relations may be more closely studied; (c) Co-operation with industrial concerns and other private agencies so that their support may be enlisted; (d) Co-operation with the public in insect control through the state, and county farm bureaus and other associations which are in intimate contact with the farmers.

To carry out such a plan of co-operation is a tremendous undertaking, but undoubtedly it can be done if the necessary organization can be brought into play. It cannot be done by one man but by a group of unselfish, optimistic and practical men imbued with the larger spirit of co-operation for the national welfare.

SOME INSECTS INJURIOUS TO SHADE TREES IN QUEBEC

By Prof. George Maheux, Provincial Entomologist

Parasitism in its widest sense is the expression of a fundamental biological law, otherwise the co-existence of so many kinds of all classes could not be possble, it seems, and keep its wonderful order; it could not keep the perfect balance of the ever-acting forces without the eternal renewal of what the inimitable Fabre calls the "le savant brigandage des êtres." The Creator is still presiding over the harmonious co-ordination of his work. In the enormous field of living things where the struggle for life knows no armistice, insects, along with microbes, play a most important part on account of their enormous numbers, their devouring activity, their marvellous vitality, and their prolificacy. There are half a million known species of insects and probably as many more to be discovered. Those who have experienced the power of destruction of these little animals cannot ignore their power as agents of disintegration in the world.

In their destructive rage insects attack both animals and plants, and as many of these are in some way useful to man, insects are arrayed against man

in a great struggle. Directly or indirectly man suffers from their attacks. On the one hand, lice, fleas and some mites live as real parasites upon man; flies, mosquitoes and other unwelcome guests of our dwellings carry germs of infective diseases. On the other hand, everything that is useful or necessary to man suffers from continual attacks from scores of insects; animals reared for his living or help live under perpetual menace of attack; vegetables, cereals and fruits so indispensable to life, trees giving beauty, shade and various products, in a word, all plants seem to be choice dishes for noxious insects. Damages run up into millions of dollars yearly in this province alone.

A study of the noxious insects of plants would be a long and arduous task and would over-run the limits of this paper. In fact it would be a long task to review the insects injurious to trees, therefore we will attempt only to outline the life histories of the more important injurious species on shade trees.

Insects naturally fall into two groups—external and internal feeders. The external feeders include caterpillars, plant lice and scale insects. Norwithstanding appearances insects of this group are not, generally speaking, the most dangerous enemies of trees. Even if a tree be defoliated it possesses the power of recuperation and, in nearly every case, will succeed in putting out new leaves, sooner or later according to its power of resistance, without much appreciable loss. It is quite rare to find a maple, an elm, a poplar or an oak die immediately after the premature disappearance of its leaves due to animal agency. Death follows only after intensive defoliation for three or four years in succession. However, scourges of insects and caterpillars manifest themselves usually with virulence only for three years and return periodically every eight, ten, twelve or fifteen years, or more frequently according to the species. Between two consecutive attaks where there has been much damage, the depredations of a leaf-eating insect can be represented by a curve, the highest points being the years of the epidemic, gradually becoming lower to the minimum which would coincide with the middle period of control, and gradually ascending again little by little; the natural enemies of the insects aiding artificial agents tend to combat them. The tree will then show every chance of surviving the assaults of the insect and of returning to the condition before it was attacked.

Like resistance is not met with among the resin producing trees—which generally show a very great susceptibility. This is due to their inability to make rapidly new foliage, little accustomed to annual renewals and to a physiological weakness belonging to an organism incapable of recovering from agencies that make for a lessening of its power. Even with essential oils conifers deprived of foliage show this characteristic weakness. One example will suffice. Canada balsam was practically wanting in our province at the close of the last century—caused by the repeated ravages of the Larch Saw Fly (*Nematus Erichsonii*). Its migration westward is due to a scarcity of victims rather than a pronounced desire for adventures.

This introduction, dealing with a few examples of leafeaters is a little long, nevertheless necessary. I shall confine myself to the species which have ac-

quired a bad reputation in the City of Quebec and the surrounding district. Of these defoliators principal mention will be made of the Tent Caterpillars, the Elm Caterpillar, and the White marked Tussock Moth.

The Tent Caterpillars (*Malocosoma americana and M. disstria*).

In 1912 countless armies of tent caterpillars completely stripped the maples and other trees that were objects of pride in the parks and along the highways. Two sister species belonging to the Lasiocampidæ family, worked concertedly—the American and the Forest caterpillars. They are very similar in habits, the first, however, preferring the apple, the second the forest trees, but both feeding upon succulent foliage of all kinds when they occur in large numbers in the same locality. It should be added that the Forest Caterpillar, in spite of its comonm name does not build a tent.

The life history of these two insects may be summarized as follows: they winter as eggs arranged as large rings, each containing 150-300 shells, around the smaller branches of the trees selected by the females for egg-laying. At the end of May or about the beginning of June, the eggs hatch and the little caterpillars make for the leaves in quest of food. The true tent caterpillars live in colonies in a sort of house made of threads secreted by the larvæ, situated at the crotch of two branches, and capable of sheltering 100-250 caterpillars.

The other species has only the power of making a silk thread wherever it goes. Up to the 15th or 20th of June the trees are either partially or wholly defoliated, according to the number of caterpillars that are working. At this time the caterpillars are about two inches long and are fully grown. They then leave the host plant and wander here and there until they find a suitable hiding place. There they form a cocoon of whitish silk within which they make their transformation to a pupa. Ten or fifteen days later, moths emerge from the cocoons. In the first days of July mating and egg-laying occur; at that time myriads of the moths can be seen flying about the lamps of our cities. The reproduction of the species having been assured the mission of the adult insect is ended and it dies. The eggs are the only evidence of life until the following spring.

The Elm Caterpillar (*Vanessa autiopa L.*)

The Elm Caterpillar belongs to the Nymphalidæ family of the Lepidoptera. It is a black caterpillar marked with chestnut spots and bearing a cuirass of long forked spines. We have found it quite numerous on the elms of the city of Quebec during the last five years. The leaves of the elm are its favorite food and it gets nourishment from them in a strange way. The green portion filled with chlorphyll is very appetizing, for after the visit there remains only a skeleton of veins covering the upper epidermis which has remained intact and become transparent, the whole assuming a yellow color.

The caterpillar does not appear until the last half of July, and it requires four weeks to attain full growth. It is then two inches long and it roams about at random seeking a suitable place in which to transform to a chrysalis. Unable to spin a cocoon it adopts the very simple procedure of suspending itself by the

abdominal extremity with the help of some threads. Soon occurs the definite moulting by which the larval skin is discarded for the narrow swaddling clothes of the pupa. Fifteen days later (August 20th—September 15th) emerges a beautiful butterfly which winters in the adult state snugly under some shelter. In the first fine days of spring the butterfly takes to flight, and deposits its eggs in long slender plates on the small branches of the elm, willow and poplar.

The White marked Tussock Caterpillar. (*Hemerocampa leucostigma*).

During the last few years the poplars, willows and climbers in many parts of the province and particularly in the cities of Quebec and Montreal have been defoliated by this caterpillar. It gets its name from the four whitish, hairy and thick-set tufts on its back. In other respects it is richly adorned with dark yellow stripes along its surface, with a red head and with two black plumes at the front and one at the rear; it is a very pretty creature. August is usually the period of larval activity, and it devours quickly all the leaves of a tree. The yellowish cocoon is attached to the bark of the trunk and branches. The wingless female does not depart very far from the cocoon but attaches herself closely to it, its mission being to lay its eggs on this silky mass. The eggs are covered by a white, frothy substance which hardens on exposure to the air and becomes a very effective protector. The male is a beautiful moth with superb wings and strongly pectinated antennæ. This species belongs to the Liparidæ family of the Lepidoptera.

So much for the first group. We shall now examine some wood-eating types that bore into wood or between the bark and the wood. The makers of tunnels under the bark are the worst enemies of trees, and for that reason they have been named "ravageurs" or Borers. From the physiological and commercial standpoint the damage done by these insects are often irremediable.

If the gnawing larvæ in any one tree be at all numerous the galleries or tunnels increase and intercross on the entire periphery of the woody cylinder. Their complex system interferes with the movement of sap in the tree and especially with the downward movement of the elaborated sap which cannot pass below the injured region.

The Sugar Maple Borer (*Plagionotus speciosus*).

This is a beautiful beetle belonging to the Cerambycidae family of the Coleoptera. The body of the adult is marked with different designs in yellow. The eggs are deposited in the bark of the maple, and several days later a pale larva, without feet, hatches out and makes its way towards the sap-wood boring its way like a gimlet. Here it digs a canal which keeps enlarging with the development of the larva which takes two years. Now at its full development the larva digs out a chamber for the pupa at the approach of winter close to the corky tissue. The following summer the newly hatched adult has only to break through the thin covering of bark to get free. It is seldom that we find more than two larvae working at the same time on the same tree. Since the tunnels are horizontal for only about one half to two-thirds of their entire length with

the remainder vertical, some of the cortical surface dries up and falls leaving bare the adjacent ligneous layers. Nevertheless the tree may continue to live.

The Bronze Birch Borer (*Agrilus anxius* Gory.)

This borer belonging to the Buprestidæ family of the Coleoptera is a scourge but recently established in Quebec. During the past seven years, numerous cut leaf birches, very handsome trees, have been killed by this insect. Unlike the sugar maple borer, the larvæ of this pest appear in large numbers on a single tree, and their numerous burrows completely cover the trunk with a labyrinth of tunnels. The small pale larva lives but one year and the following spring the adult leaves the tree by an elliptical opening. This adult is a small bronze black, cylindrical insect. It is safe to say that a birch when once infested with this borer is bound to die within two or three years.

The Poplar Borer (*Saperda calcarata* Say).

Although less decorative than the birch, the species of the Populus are widely planted here as ornamental trees. They are unfortunately the victim of many diseases of fungous and insect pests of which the Saperda is one of the most important. The larva is thick and fat and bores its tunnels vertically right in the sap wood. These are like gimlet holes and are filled with coarsely torn fibres and woody particles with which the larva surrounds itself at the time of metamorphosis. Since it grows for three years constantly increasing in size, the burrow becomes very wide and causes serious derangement in the life and growth of the tree. The adult is a beautiful insect covered with a greyish down, sometimes colored with brown or yellow. The insect belongs to the Cerambycidæ family of the Coleoptera.

Poplar and Willow Borer. (*Cryptorhynchus lapathi*).

This insect was practically unknown here ten years ago but is found now in several places. As to its origin there seems to be no doubt that this wood borer was introduced from Ontario and is still coming in with plants imported from that province. It attacks with preference Carolina Poplars which succumb to its depredation a year after they are planted. The larvæ bore into the young trunk in several places and kill the outside portion, but fortunately the poplar rebuilds new tissue from the base of the trunk.

The larva is pale and fleshy. The adult has a rather small body, black in color, with the extremities of the wings greyish and sometimes pink.

Conclusion

We can only preserve our ornamental trees intact by exercising the necessary precautions. Essential measures consist in keeping the trees tidy, the removing of the diseased portions and the cleaning of the bark. In case of an epidemic of caterpillars the tree may be preserved by the timely application of arsenical solutions. Wood borers may be easily exterminated with carbon bisulphide. Finally, in the spring and fall, eggs, cocoons, etc. should be collected

and immediately burnt. Gummed bands applied to the trunk will protect the tree very effectively against many marauders from outside especially caterpillars.

The measures outlined above should help to prolong the beauty of our ornamental trees.

DISEASES OF THE POTATO *

By B. T. Dickson, B. A., Ph. D.. Professor of Botany, Macdonald College

Introduction

The potato crop is of prime importance to Canada and therefore the importance of a knowledge of the diseases of the potato need not be stressed here—it should be taken for granted. Without quoting statistics, the losses from potato diseases amount to millions of dollars every year. This means that every year a percentage of the seed planted is useless, that a part of every acreage is wasted, that labor is not used to full advantage and, finally, that the grower suffers a direct financial loss whether he is growing potatoes for sale or use.

In dealing with this series the diseases will be considered in the order now given.

1. Diseases in which insects are the agents of infection or in which insects are the direct cause:—
   - (a) Hopperburn.
   - (b) Mosaic and mosaic dwarf.
   - (c) Leaf roll.

2.—Disease caused by a myxomycete:—
   - (a)— Powdery scab (*Spongospora subterranea*).

3.—Disease caused by bacteria:—
   - (a) Black leg (*Bacillus atrosepticus.*)

4.—Diseases caused by Phycomycetes:—
   - (a) Black wart or potato canker (*Chrysophlyctis endobiotica.*)
   - (b) Leak (*Pythium de baryanum*).
   - (c) Late blight (*Phytophthora infestans*).

5.—Disease caused by an Ascomycete:—
   - (a) Wilt and stem rot (*Sclerotinia libertiana.*)

6.—Disease caused by a Basidiomycete:
   - (a) Dry stem rot and black scurf (*Corticium vagum*).

7.—Diseases caused by Fungi imperfecti:
   - (a) Early blight (*Alternaria solani*).
   - (b) Wilt (*Fusarium oxysporum*).

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(c) Common scab (*Actinomyces scabies.*)
(d) Skin spot (*Oospora pustulans*).
(e) Silver scurf (*Spondylocladium atrovirens*).
(f) Dry rot of tubers (*Fusarium spp*)
(g) Fusarium net-necrosis (*F.oxysporum*).
(h) Black dot disease (*Vermicularia varians*).

8. Diseases caused by conditions which adversely affect the normal physiological processes:

(a) Black heart.
(b) Frost necrosis.
(c) Net necrosis.
(d) Internal brown spot.
(e) Spindling sprout.
(f) Hollow heart.
(g) Arsenical injury.

9. General considerations in control.

It will thus be seen that there are some twenty or more common potat diseases with which the growers may have to contend at different seasons.

GROUP 1.

In this group are placed three (or four) diseases in which insects play an important role.

(a) *Hopperburn*, or "tipburn" as it used to be called, occurs periodically whenever dry conditions prevail in potato growing areas. It was noted first in Iowa in 1876 by Osborn, but wilting of early varieties was the most pronounced characteristic. Osborn recorded the presence on such diseased plants of *Empoasca Mali* (Le Baron) known as the leafhopper. In 1908 its work was observed in New York, and again in 1909. Fraser reported it from Quebec in 1913, it was again serious in Iowa in 1915, and in Vermont in 1917. Ball in Wisconsin, in 1918, studied the disease which that year extended from Montana and Kansas to New York and New Jersey. This year the leafhopper was very prevalent in Quebec and hopperburn is certain to have caused considerable loss (1921).

Symptoms of the Disease

The first signs of the hopperburn usually appear during the latter part of July or early in August with most severe effects from the middle of August to the middle of September. On some of the lower leaves a slight yellowing begins at the tip or edge of terminal leaflets. As the injury progresses the yellow areas become brown, curl up and dry out. Thus the leaflet finally possesses a dark-brown, dried, uprolled margin with a band of green in the middle bordering the midrid (see plate). The remaining leaflets gradually become affected so that the whole leaf is involved (plate). When the season is hot and dry such leaves shrivel completely, the petiole gradually dries towards the stem and hangs limp so that a touch will cause it to drop. Whole fields may succumb to this injury

in a period of two dry hot, weeks so that a "burned over" appearance is given to the crop. Usually, however, the upper, young parts of the plants escape burning for a time owing to the fact that the adult females prefer young growing tissues for oviposition. It is not until the eggs hatch and the nymphs begin to feed that injury is noticeable in these parts. The nymphs, because they do not migrate rapidly, are restricted in their feeding to the area in which they were hatched, consequently causing severe injury in that area. Adults, on the other hand, fly at the slightest disturbance and thus their effect is more distributed.

During cool moist weather the burning is checked and this also applies to plants which have been sprayed with Bordeaux.

Effect on Plant

The eggs are laid on the midrib and petiole of the potato leaf and when hatched the nymphs feed mostly by sucking juice from the larger veins in the upper part of each leaflet. This reduces the supply of sap for the smaller veins at the margin and tip of the leaflets and accounts for the fact that browning, rolling and drying out occur at the tip and margin. There is thus a direct loss of sap from the leaves followed by the death of large areas of leaf tissue. This occurs at the time when maximum growth rate of tubers should occur. Consequently the tubers suffer and the greater the area of foliage affected the more severe the effect on the tubers. In cases where defoliation is complete, or nearly so, the crop is a total loss.

Other Hosts

Field observations show that this insect may live temporarily on many hosts among which are: bean, apple, beet, rhubarb, raspberry, red clover, Swiss chard, strawberry, cucumber, lettuce, dahlia, hollyhock, elm, box-elder, burdock, rose, etc.

On some of the above the leaf-hopper merely feeds, but on beet, apple, beans and box-elder it will also reproduce.

Life History

The potato leafhopper (*E. Mali*) lives over winter in the adult stage in protected places such as among thickly growing weeds, in brush, etc. In June they come out from their resting place and feed for ten days or so on the apple and other trees and shrubs, and at this time females predominate. At the end

of the feeding period they migrate to potatoes and beans and begin mating and egg laying.

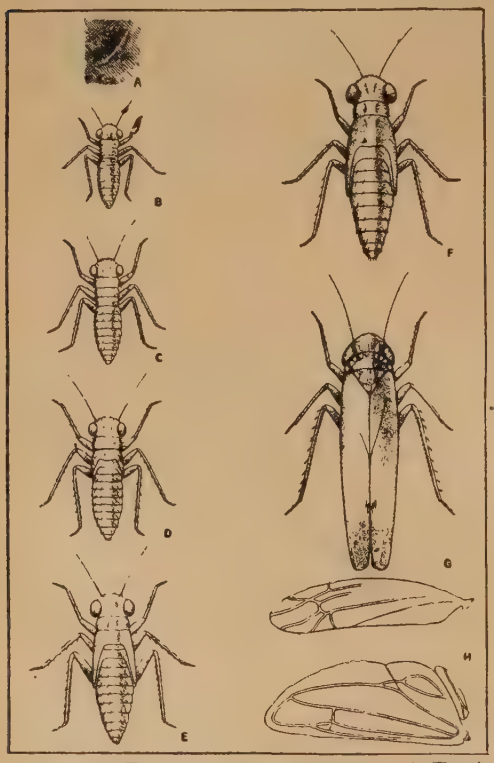

Fig. 1 THE POTATO LEAFHOPPER.—A. Egg in leaf tissue; B. First nymphal stage; C. Second stage; D. Third stage; E. Fourth stage; F. Fifth stage; G. Adult stage; H. Outer (elytron) and inner wing, showing venation. After Bull, 334, Wisconsin University Agr. Exp. Sta.

The eggs are about $^1/_{30}$ of an inch long and are transparent at first. They are deposited in the petiole and midribs of leaves where they change from transparent white to yellow. In from ten days to two weeks the eggs hatch and the young nymphs appear as whitish, wingless hoppers. They begin to feed at once and as they absorb the plant juice they grow and become green. They shed the skin five times during their growing season and become winged adults in about seventeen days. When quite young they are to be found mostly on the lower side of the leaves and they move about but little.

The adult females have a long egg laying period and nymphs in all stages may be found up to the time of the first frost.

The first generation of the season causes the first noticed hopperburn on the potatoes. Adult females of this generation give rise to a second generation during the season and usually the severest attack of hopperburn occurs at the period when adults of the first generation and nymphs of the second generation are feeding at the same time. The over—wintering leaf hoppers are members of the second generation.

Varietal Susceptibility

In Quebec the Irish Cobbler appears to be more susceptible to leaf hopperburn than Green Mountain. Unfortunately the writer does not happen to have at the present moment facts relative to susceptibility for other potato growing areas of Canada. In Wisconsin Early Triumph is affected worst and Rural New Yorker least . An important point to notice is that early planted potatoes are liable to suffer more from hopperburn than late planted varieties. It is also

significant that plants from seed of diseased vines always suffer more severely than plants from seed of healthy vines.

Control

Spraying with Bordeaux 4-4-50 is effective in controlling hopperburn provided that the underside of the leaves is sprayed thoroughly. This is obvious when considering the fact that nymphs feed on the underside of leaves as above noted.

(b) *Mosaic and Mosaic Dwarf.*

W. A. Orton first described Mosaic as a disease of potatoes from observations he made in potato fields at Giessen while visiting in Germany, although Quanjer believes that the disease has been known for a long time in Europe. Orton on his return found the disease to be quite prevalent in Maine in the Green Mountain variety. This was in 1912 and since that time the disease has been found in practically every potato-growing area of the United States and Canada.

The cause of the disease is not yet determined, although it is certainly a systemic disease, and it has been placed here in Group 1 because of the established fact that aphids are agents of inoculation.

While the disease may be regarded as new, as compared with Late Blight for instance, it is highly infectious and has spread with alarming rapidity. In 1919 careful estimates made in Aroostook County, Maine, of 40 fields of Green Mountain and the same number of Bliss Triumph showed an average of 28 per cent of infected hills of Green Mountain and 46 per cent in the case of Bliss Triumph. In some cases the diseased plants amounted to 100 per cent. It is therefore of paramount importance that efforts be continually made to check the spread of this insidious disease. The difficulty involved lies in the fact that the potato tuber, a vegetative part of the plant, is used for seed purposes and the causal principle may be present in the tubers as a result of late infection without there being distinct signs of the disease in the foliage.

Symptoms of the Disease

The disease may manifest itself in either of two ways according to the variety or according to the locality. The typical symptom from which the name arose is the mottling of the foliage. Lighter green areas occur in the leaves and these lighter green areas may be few or numerous, they may be very small or reach the size of a quarter of an inch, and in shape are usually angular. The leaflets may also be more or less ruffled or wrinkled owing to the modified growth, and where this is the case the wrinkles are likely to obscure the mottling at first

sight. The above symptoms are typical for Green Mountain potatoes. It might be added for those readers who have at their disposal a microscope that a thin freehand section through a light green area bordered with the dark green will show, even under the low power, that in the light part the palisade tissue has not been able to develop normally. The cells instead of being from four to six times as long as wide are approximately cubical or distinctly shorter.

Fig. 2—Plant A is healthy. Plant B is suffering with mosaic. Note at 1 the scars left by fallen leaves and at 2 a leaf which has just dropped.

The Irish Cobbler, on the other hand, exhibits different characteristics. Here mottling is not usual but instead the leaves of affected plants are extremely wrinkled and dwarfed. The leaflets are smaller, the petioles are reduced and even the haulms are dwarfed This gives rise to a type known as *Curly Dwarf* in extreme cases. The Rural varieties also show this group of symptoms.

With regard to locality it is interesting to note that with the same variety the symptoms differ according to whether the variety is planted in a northerly or cooler district, or in a more southerly, warmer place. In the cooler locality mottling is pronounced whereas in the southerly, warmer district mottling is reduced or altogether obscured. That the plants are still diseased, however, is proved by the fact that if tubers from a plant grown under the latter conditions be planted further north mottling is again pronounced.

In addition to the above symptoms it is to be noticed that plants severely affected with mosaic will show this in weaker stem development and in a generally unthrifty condition.

Effect on the Plant

One effect of the disease has already been mentioned, namely the modified growth of the palisade cells in light green areas. Other cells are affected to a less noticeable extent but the general effect is that the tissues which should be manufacturing a maximum amount of starch are not able to do so, and further a proportion of that manufactured is undoubtedly used by the causal principle. This is postulating that the causal principle is a parasite. Hence the amount of food

available for tuber formation is reduced according to the severity of the disease and the duration of it in the particular plants. The tubers are therefore reduced in size or in number, or both. In the case of late infection there is not likely to be any noticeable difference in the tubers. Murphy has estimated that severely diseased plants yield only 57.8 per cent of a crop as compared with healthy plants of the same variety under the same cultural conditions.

Infection

Gussow has shown that by grafting the disease may be readily transmitted, and Folsom *et al.* have obtained similar results in Maine. The writer in unpublished work has found aphids to be fertile sources of infection, and Folsom et al. have carried on extensive experiments in Maine proving clearly that plant lice, (*Myzus persicæ* Sulz. and *Macrosiphum solanifolii* Ashmead) are carriers of the disease from plant to plant. The writer has found that aphids are also most important in the transmission of clover mosaic and it is probable that they play a part in most mosaic diseases.

Other potato pests, such as the Colorado potato beetle and the flea beetle, are not found to be carriers of the disease.

Experiments also indicate that the seed cutting knife is not important in transmitting the disease. The same applies to contact in the field between healthy and diseased plants. Soil has not been found to transmit the disease from one season to the next, but it may be possible that volunteer plants arising from diseased tubers left in the soil will give rise to centres of infection the following season.

Fig. 3—A leaf of potato showing mosaic mottling. Note at 1 a flea-beetle hole and at 2 a typical light green area.

Varietal Susceptibility

Little is yet known of this phase of the question and work on it is difficult because of the carrying over of diseased tubers which came from apparently healthy plants. It is known, however, that on the whole the Irish Cobbler variety is less susceptible to the disease while Green Mountain is particularly susceptible.

Control

Three points in control are empha-

sized. If the grower prefers to use his own seed the seed plot should be isolated from other potato patches in order to reduce the possibility of infection by means of aphids. It follows that the seed tubers used should be healthy as far as it is possible to ascertain this fact. If diseased plants are observed they should be rogued at once and if aphids are seen on the diseased plants when rogued a careful inspection should be made of the plants immediately surrounding. Any plants upon which aphids are found should also be removed. Finally, since aphids are the prime carriers of the infective principle it is necessary to control plant lice. To accomplish this, add ¾ of a pint of "Black Leaf 40" to every 50 gallons of Bordeaux mixture and spray to cover both the upper and under sides of the leaves.

Before leaving the subject of mosaic, mention should be made of a peculiar condition found in severely diseased plants by Gussow and also by the present writer. In the leaves small, angular areas suddenly become brownish and necrotic. In the petioles brown streaks appear just below the epidermis and later similar lesions develop in the stem. Soon after the lesions appear the petiole collapses and the leaf withers, hanging by a mere thread. It then falls and as the whole plant is rapidly affected a very characteristic appearance is given. This is shown in Plate 3 plant B. It cannot be stated for certain that this is a type of severe mosaic, but the writer has not observed similar conditions in other than mosaic diseased plants of the Green Mountain variety.

(c) *Potato Leaf roll.*

The disease known as *"Leaf roll"* is, like mosaic, comparatively new and in many respect it resembles mosaic. It is infectious, is transmitted by plant lice, it is systemic, and is controlled in the same way.

Symptoms of the disease

The name suggests the outstanding symptom but care must be exercised in differentiating the rolling of the leaves in this disease from rolling in wilt diseases and in cases of either excessive moisture or continued drought. In true leaf roll the leaflets are distinctly rigid and not in the least wilted. They are uprolled so that the two margins tend to come together forming a trough like structure. They are lighter green than normal leaves and in severe cases of the disease they may be yellowish, reddish or purplish. The plants are dwarfed having shorter petioles and haulms than normal, and the whole plant has a typical aspect owing to the angle of development of the petioles. Instead of being rather spreading as in a healthy plant the leaves and branches tend to assume an angle of approximately 45 degrees from the main stem. The stolons bearing

tubers are considerably shortened and the tubers are smaller, fewer, and are conspicuously harder than tubers from healthy plants. This hardness of the tubers is maintained even for considerable periods in storage.

Fig. 4—A leaf showing the dwarf, curled, dark green symptoms of mosaic. There are no apparent light green patches.

The rolling usually appears in the lower leaves first but a late infection may affect only the leaves last developed.

Effect on the Plant

As with mosaic the leaves of potatoes suffering from leaf roll do not function properly. The causal principle is translocated in the plant juices and in this case it especially affects that part of the vascular tissues known as the phloem. In the phloem it gives rise to a necrosis or death of the tissue. Since it is in the phloem that most of the conduction of elaborated food takes place, those parts awaiting supplies of food for their development will receive only a much reduced amount. This is the case with the tubers and the stolons bearing the tubers. Hence those tubers which do develop are small and are borne on short underground stems. Moreover the infective principle passes down the parts of the phloem not killed and reaches the vascular tissues of the developing tuber. In it, therefore, there may also be phloem-necrosis. When such a tuber is cut across, or when it is pared to expose the vascular tissues, these are seen to be browned. The general term "*net-necrosis*" is used to indicate such an appearance, but it must be recollected that net-necrosis may be caused by other conditions than those in leaf-roll. Moreover the tubers from a plant with leaf-roll do not necessarily develop net-necrosis, for they may not be affected soon enough, nor sufficiently severely, to cause necrosis in the vascular tissues. A further effect on the plant is exhibited in the next generation for tubers from diseased plants, and especially those with net-necrosis, frequently develop very weak, spindling sprouts.

The yield from leaf-roll plants is materially reduced, in many cases being nothing at all.

Infection

The tubers transmit the disease as in the case of mosaic, but an additional fact must be mentioned, namely, that in the progeny of plants with leaf-roll there is a much more rapid depreciation in yield and accentuation of the disease than is the case with mosaic.

Tests conducted in Maine show that aphids again are the only insects of importance in transmitting leaf-roll. The seed-cutting knife is not a factor in the spread of the disease.

Varietal Susceptibility

Red varieties are usually more susceptible than white varieties. Garnet Chili, Davies Warrior, Irish Cobbler, Early Puritan, Early Six Weeks, Dakota Red and McIntyre develop the disease more severely than Carman, Green Mountain, and Empire State. The last named at times appears to be free and at others is severely affected, due in all probability to lack of inoculation by aphids.

Control

The same points mentioned for the control of mosaic apply to the control of leaf-roll.

GROUP 2.

Diseases caused by Myxomycetes or Slime Moulds

There are certain organisms which have not yet been definitely assigned to the animal kingdom nor to the plant kingdom, because during part of the life history they move, feed and grow in such a manner that they are more animal like than plant like, while the reverse is the case at reproduction time. Such organisms are known as "Myxomycetes" and usually they are saprophytic. Two, however, are parasites causing diseases of considerable economic importance, viz., "Club root" of cabbage, cauliflower, brocoli etc., and "Powdery scab" or "Corky scab" of potato. This latter disease is caused by a slime mould known as *Spongospora subterranea* (Wallr.) Johnson.

Powdery Scab or Corky Scab (*Spongospora subterranea*)

Occurrence

The disease has been known in Europe for nearly eighty years being described first by Wallroth in 1842 and it was noted by Barkeley in 1846 in England. The former investigator, however, considered that the disease was a smut.

Brunchorst, in Norway, in 1886 studied the disease and named the causal organism *Spongospora*, placing it among the Myxomycetes. Gussow was the first to find the disease on this continent, some potatoes with typical scab spots being sent to him from several localities in Canada in 1912. Morse and Melhus then found evidence of the existence of the disease in Maine in the summer of 1913. It is now known to be present in Great Britain, Ireland, Northern and Central Europe, South America, Eastern Canada and in several northern localities of the United States of which the most important was Maine. Dr. Morse, Director of the Maine Station, has informed the writer in correspondence that Powdery Scab has not been found to any extent during the last five or six years in Maine. That a similar situation occurs in New Brunswick is borne out by correspondence between Dr. Morse, Mr. Cunningham and the writer.

Symptoms

The name of the causal organism indicates that only underground parts are attacked, namely roots, stolons and tubers. Roots are affected earlier in the season and on them white galls develop, looking remarkably like the nodules on the roots of leguminous plants. Similar galls are produced on the stolons and less commonly on the part of the stem underground. Roots of all ages may be affected.

On the tuber the pustules begin to appear a little later in the season, usually when the potatoes are already of a fair size. The stem end is frequently first affected but as the tuber matures pustules may be found anywhere on the surface.

The first sign is a tiny, brownish purple pimple on the surface surrounded by a more or less translucent zone, the whole not exceeding one twelfth of an inch in diameter. This spot increases in size and the skin is gradually separated from the tissues below, which are stimulated to abnormal growth so that the protuberance is formed. Usually the epidermis is ruptured by this growth just about the time the organism is ready to go into the spore stage. The turned-back epidermis is typical of the pustules of powdery scab in uninjured specimens. As the parasite matures the host cells are invaded, broken down and killed so that only remnants are found. At this time the parasite ceases its vegetative life and forms spores which are aggregated into balls. It is the spore balls together with remnants of cellular tissues which form the powdery mass found in the pustules at maturity and which account for the common name "Powdery Scab". If one rubs out the powdery mass the tissue below is seen to resemble the epidermis of the tuber to a certain extent and in fact there is present a layer of cells functioning as a cork layer, which fact accounts for the other common name for the disease—"Corky Scab".

In Europe, Great Britain and Ireland, a more advanced stage of the disease is found where the tuber as a whole is malformed and tissues severely disorganized, this is known as the canker stage. That it does not occur in this country is probably due to the shorter growing season.

Life History

Spongospora subterranea requires an abundant supply of moisture for germination, as well as warmth. Hence it is that the disease is more serious in poorly drained soils or during highly humid seasons. The spores in the spore ball germinate giving rise eventually to naked masses of protoplasm known as "plasmodia". A plasmodium moves slowly over a surface which is moist by means of pseudopodia which are merely protrusions of the naked protoplasm. In this way, by moving in soil water among the interstices of the soil, the plasmodia reach roots, stolons and tubers. Whichever the part attacked, the plasmodium penetrates the epidermis and gradually passes down to the cells below. These are stimulated to excessive growth so that "giant cells" are formed which may also divide, thus giving an abnormal number of cells in the tissue and accounting for the gall formation on root and stolon and the protuberance on the tuber. In root and stolon galls the parasite eventually reaches the phloem in which most of the food manufactured is conducted and in this tissue most of the hypertrophy occurs. The tuber is somewhat modified because of its function as a large storage organ and the plasmodia do not, as a rule, reach the phloem but attack cells of the hypodermis and cortex.

Fig. 5—Roots of potato with galls caused by Spongospora subterranea

Where a cell is covered by a plasmodium or part of one, the wall swells and softens. That it is changed chemically is shown by the modified staining. Through the softened wall the plasmodium penetrates by protoplasmic protrusions which Kunkel calls "infecting pseudopodia". Once inside the cell, the naked protoplasm of the myxomycete penetrates the limiting membrane of the host protoplast and the two protoplasms are to an extent miscible. It is when the cell is thus infected that hypertrophy begins. As the vegetative growth of the potato gradually ceases and maturation commences the spores of *Spongospora subterranea* are formed and these spores are aggregated into round masses known as spore balls. Such groups of spores are highly resistant

to adverse conditions and are known to be able to live over in the soil at least three years.

Fig 6—Black-stem of potato. Note the blackened tissues at A and also the rolling of the leaves. (After Coons, Mich. Bull. 85; Fig. 7 also.)

Before leaving this discussion mention should be made of dry rots following *S. subterranea.* If, in the development of the pustule, it happens that the cork layer which cuts off the parasite is not laid down, drying-out or dessication follows in storage. The severity of this depends upon the number of pustules on the surface of the tubers which are not limited by a cork layer. It often happens that the spore balls are still present in the pustule in storage and if the temperature conditions are satisfactory for germination, the spores in the balls will germinate and the resulting plasmodia will destroy cells surrounding the old pustule.

Naturally such pustules are open places for the entrance of wound parasites and one of the most important of these, *Phoma tuberosa* Melhus et al, causes serious dry-rot injury.

It must be pointed out that, secondary Spongospora injury, dry-rot and dessication may occur together in some cases.

Varietal Susceptibility

Nothing can yet be said regarding resistance to this disease since it is probable that all the well-known potato varieties may be affected. Seasonal differences may account for some varieties escaping infection during one season but being affected another.

Other Hosts

It is interesting to note that the roots of tomato are susceptible to infection by *S. subterranea* and that galls are formed similar to those on potato roots.

Control

The following points are important in control:

1. Seed tuber selection.
2. Seed tuber treatment (formaldehyde, hot or cold).
3. Destruction of spore balls in diseased tubers by boiling before using as feed.
4. Sulphur 900 lbs. per acre applied broadcast reduces the amount of infection.
5. Practise long rotation if the attack is severe.

Skin spot

"Skin spot" caused by *Oospora pustulans* is placed among the diseases caused by Fungi imperfecti. Potatoes with a spot apparently exactly like that caused by *O. pustulans*, as described in England, were found in shipments to the Spokane market from British Columbia. In fact Heald found that 95 per cent of the tubers showed lesions. The spots are circular, brown and small when young, darkening with age. At first the spots appear slightly elevated but later somewhat depressed. Under moist conditions sporulation and growth occur in the lesions so that further necrosis occurs. Shapovalov, in a paper given at the Toronto meeting of the American Phytopathological Society, states that the pustules are identical with those of the immature or closed-sorus stage of powdery scab. This author investigated the fungi which, as secondary organisms, invade the "skin-spot" pustules and found that they varied with the locality.

GROUP 3.

DISEASES CAUSED BY BACTERIA

Black-leg or Black stem-rot

(*B. atrosepticus v. Hall*).

The most important disease of potatoes caused by bacteria is that known commonly as "Black-leg". Other names are:— "Basal stem rot","Bacterial black rot", "Black shank disease", "Black stem-rot".It is obvious that "Black leg" is an unfortunate name and that "Black stem-rot" or "Bacterial black rot" would be preferable. Throughout the course of this discussion, the name used will be "Black stem-rot".

Occurrence

Black stem-rot of potatoes occurs in Northern and Central Europe, Great Britain, Ireland, Canada and the United States. Its economic importance varies with the season, being pronounced in moist, cool seasons. Murphy states that, in 1915, 7 p.c. of the crop in New Brunswick and 10 p. c. in Nova Scotia and Prince Edward Island were destroyed by this disease. In Ontario still greater losses occur in years suitable meteorologically. A black stem-rot of potatoes was described first in America by Harrison in 1906.

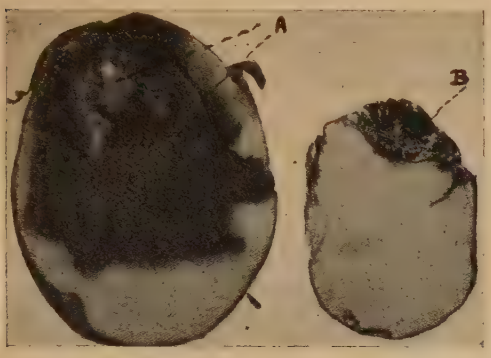

Fig. 7—Rot of tubers caused by the blackstem organism. Note at A the canals with creamy bacthe terial slime. Note at B the stemend rot of tuber.

Symptoms

Infected plants usually begin to show late in June or early in July and are quite prominent by the mid dle to the end of July. Such plants are somewhat dwarfed, although not necessarily markedly so, and their leaves are pale or yellowish. Rolling of the leaflets along the midrib, somewhat as in true Leafroll, occurs but it can be distinguished by the fact that the leaflets are not rigid and brittle. If the infection happens to occur after the plant has grown considerably, and if the infection also happens to progress rapidly because of suitable humidity and temperature, the growth of the upper part of the plant will be suddenly checked. Thus internodes are shortened and leaves considerably dwarfed giving rise to a "rosette" top. If the attack is still more sudden and severe the stem may wilt suddenly and fall over without previous symptoms other than the flaccid leaves.

On pulling gently at such stems they easily come away at the level of the ground because there the tissues are rotted through. (Fig. 6.) From the rotted stem tissues the bacteria may travel along the stolons to the tubers. In these, if conditions are suitable for the organism, a total rot may occur, but if conditions happen to be less suitable only stem-end infection may occur. This may not be easily visible to the naked or unobservant eye and yet it is the important factor in overwintering.

Life History

The organism overwinters in the stem-end of slightly diseased tubers where a low temperature, keeps it dormant. It is found that growth is slow at 46 deg. F. and it ceases at 39 deg. F.

The organism attacks parenchyma cells dissolving the middle lamellæ and this accounts for the typical soft rot which occurs. It does not specifically

attack vascular tissues but by rapid multiplication the bacteria plug up the xylem thus preventing the upward passage of water and accounting for the rolling of leaves, rosette top and wilting.

As to the organism causing the disease it is highly probable that more than one may give rise to similar symptons. Morse inclines to the view that in Maine it is *B. atrosepticus* van Hall. This typically attacks stems but does not cause excessive tuber rot. Harrison, from Ontario material, described *B. solanisaprus* which caused severe tuber rot in addition to black stem rot. This was the first description of such a disease in America. It has since been found in Michigan (Fig. 6) but is ascribed by Coons to *B. atrosepticus* van Hall. In the Western and irrigated parts of the United States an organism causing a similar tuber rot and stem-rot is ascribed by Shapovalov and Edson to *B. phytophthorus* Appel.

Control

Whatever the specific organism it is reasonably certain that in Canada it cannot overwinter in the soil. Hence it is to the seed tuber that one must look for control. The chief points to bear in mind are:

1. To select sound tubers for seed.

2. If it is impossible to guarantee the soundness of the seed tubers then treat with formaldehyde—2 pints in 30 gallons of water at 119 deg. F. to 122 deg. F. for two minutes. The tubers are then covered for one hour and dried. This treatment is recommended only as a good general measure since it is obviously impossible by external disinfection to affect bacteria in the tissues.

GROUP 4.

Diseases caused by Phycomycetes

The Phycomycetes are the alga-like fungi, as a rule possessing non-septate vegetative mycelium and developing both sexual and asexual spores. In some cases the mycelium is profuse and in others it is reduced to a minimum. Zoospores or motile spores are produced in the cases under consideration.

(a) Black Wart or Potato Canker

This is one of the most serious and virulent of potato diseases and is now known to occur in England, Scotland, Ireland, Scandinavia, Germany, France. Italy and it has been reported from Africa. It is common in Newfoundland but is practically confined to Pennsylvania on the continent. In Pennsylvania the report by McCubbin showed that in 1920 the disease occured in 781 gardens in 53 towns of 9 counties, so that the area involved covers approximately 3,000 acres although the actual areas total about 100 acres.

The disease is known under various descriptive names, such as Cauliflower disease, Black Scab, and Wart disease, but Potato Canker or Potato Wart are more commonly accepted. Schilberszky discovered the disease in Hungary in 1896 and attributed it to *Chrysophlyctis endobiotica*. Percival, in 1910, made

further studies and named the causal organism *Synchytrium endobioticum.* Its appearance on this side of the Atlantic was first announced by Gussow in 1909 from Newfoundland material.

Symptoms

On above-ground parts there are rarely any symptoms but occasionally the fungus may gain entrance to the haulm, lower axillary buds or leaves. If this happens the infected tissue is stimulated to excessive growth giving rise to variously shaped excrescences. It is on the tubers that the symptoms are usually found and here the buds or eyes are affected. Diseased buds are stimulated to such hypertrophic growth that they may be no longer recognisable.

Fig. 8—Potato Canker.—Susceptible variety (Cumberland Ideal) showing effect on tubers. Two cankers on above-ground parts can be seen. (From Supplement 18 to Jour. Bd. Agric. Eng. 1919.)

If the eye is affected late in the season of its growth, the nodular excrescences may be noticeable only on careful examination. But if the eyes are attacked while the tuber is quite young the excessive growth of the tissues will give rise to nodular masses entirely unlike a tuber. (See Fig. 10). The demand for food on the part of the organism will be so great that any stored in the developing tuber will be used and the tissues will collapse. In this necrotic condition lies the greatest danger. It is impossible to harvest such diseased tubers without leaving behind fragments, which are filled with sporangia, in the soil. The resting sporangia thus left behind may remain viable for several years and constitute a source of infection if potatoes of a susceptible variety are planted. Cases are on record in which the disease has reappeared after an interval of ten years in England.

Life History of the Fungus

The resting sporangia which average about 52 microns in diameter contain many round zoospores which

measure 2½ microns in average diameter. In the spring the resting sporangia may germinate and the released zoospores are motile in the soil water for a time. Eventually they become amoeboid by the withdrawal of the single cilium and in this stage they enter the young tissues of stolon or buds. After the infected tissues have been depleted of food the fungus in each cell rounds up, develops a protective wall and becomes a summer-resting sporangium. This may germinate, the resulting zoospores giving rise to secondary infections. Toward the close of the growing season winter-resting sporangia are formed in a similar manner. Another type of summer sporangium is that in which thin-walled structures, sometimes in groups, are developed in a sorus. Each thin-walled sporangium contains numerous zoospores which are smaller than those from the ordinary type of resting sporangium.

Other Hosts

To date the tomato is the only other host known to be susceptible in America. In England *Solanum nigrum* and *S. dulcamara* are slightly susceptible.

Varietal Susceptibility

The work of Weiss and Orton shows that Green Mountain, Cobbler and Burbank are immune while Rural New Yorker, Early Ohio, Early Rose, Triumph, Pearl and Up-to-Date types are susceptible.

Control

This disease does not, so far as in known, occur in Canada and samples of any doubtful tubers should be sent immediately to a reputable authority for determination. Where the disease does occur the only control is the planting of immune varieties.

(b) Leak of Potatoes

With the development of distant markets storage and transit diseases are of increasing economic importance. "Leak" is one of the most serious of these diseases. It has been ascertained by Link that "Leak" is practically co-extensive with the potato crop of the United States. So far as the writer knows, it has not been reported from Canadian markets.

Symptoms

The disease is first apparent as a small brown discoloration around a wound such as might be caused during digging. The causal organism lives in soil and can enter the tuber only through wounds exposing the inner tissues. The fungus grows through the tissues causing the tuber to become brown over the entire

surface. . In this condition it is soft, easily crushed and pressure causes the exudation of a brownish watery liquid. In advanced stages the symptoms might frequently be mistaken for those of tuber rots caused by Fusarium species.

Life History of the Fungus

Orton has shown that a similar rot may be produced by *Rhizopus nigricans* Ehrenb but the work of Link demonstrates that "Leak" is usually caused by *Pythium debaryanum* Hesse.

This fungus is aggressively parasitic if humidity and temperature conditions are satisfactory and is the common cause of "damping off" in green houses and nurseries. The mycelium is cœnocytic, except with age, irregularly branched and rather coarse. Conidia are produced terminally on branches of the mycelium or they may be intercalary. They are globose to elliptic and average 22 microns in diameter. They may germinate at once by one or more germ tubes. Oospores are also produced which are smooth, spherical and thick-walled and able to live over an adverse period. Growth is slow at 48 deg. F. and practically ceases at 41 deg. F. while it is best at about 86 deg. F. In an experimental inoculation Link found that at 86 deg. F. the fungus penetrated to a depth of 4 cm. (1½ ins.) in 67 hours.

Varietal Susceptibility

Rurals and Burbanks dug during warm weather are especially susceptible and inoculation experiments by Link tend to show that Triumph, Green Mountain, Early Ohio, Rural New Yorker and Irish Cobbler are susceptible.

Control

The disease can be controlled by care in harvesting and handling potatoes and by sorting out wounded tubers.

(c) Late Blight and Rot

This disease, caused by *Phytophthora infestans* (Mont.) De Bary, is too well known to need emphasizing as to its economic importance. It is not often that a fungus can materially affect the policy of a country but this is what *Phytophthora infestans* did in Great Britain. Late blight was so serious in 1845 in England and Ireland that the potato crop was a failure. So much was this the case in Ireland that a famine occurred and many thousands of Irishmen left Ireland for America. To relieve the distress the Corn Laws were repealed and in a sense this initiated a Free Trade policy.

The disease is now controllable so that epiphytotics are rare; nevertheless a warm, wet summer is a season of worry to the potato grower in the Maritime Provinces, Quebec, New England States and New York. It is common in Europe from east to west where the growing season is moist and mild.

Symptoms

Irregular spots at the margins or tips of leaves are produced which are at first water-soaked. The position of the lesions is due to the drainage of the water on the leaf surface in which the spores germinate. If the weather becomes dry the lesions turn brownish and dry out more or less. Under humid conditions the mycelium in the leaf tissues grows rapidly and sends out through stomata in the lower surface branches which abstrict conidia in profusion. The conidiophores are usually so numerous under these conditions that a distinct pale violet tinge is given to the affected lower surface. If the disease is not checked the leaves are rapidly destroyed and gradually the stems are affected.

On the tubers the first symptom is a slight darkening of the skin over an infected area. Later this area becomes slightly sunken and a dull reddish-brown in color. Gradually the mycelium of the fungus penetrates the tissues, causing a dry-rot if no secondary organisms are present.

A general symptom in a seriously affected area is the odor, which is difficult to describe but is something like stale herring-brine.

Life History of the Fungus

Most Phycomycetes live over adverse seasons as a sexual structure known as an oospore. It was therefore natural to look for oospores in *Phytophthora infestans* but not until 1875 was any statement made that oospores had been found. De Bary had studied the disease previously and concluded that the fungus lived over in the tuber. In 1875 Worthington G. Smith announced that he had found oospores of the fungus. De Bary again studied the case and again concluded that mycelium lived over in the tuber. Since then, L. R. Jones (1909), Clinton (1911) and Pethybridge and Murphy (1913) have found oospores in pure cultures of the fungus. The work of Melhus (1915) shows that mycelium living-over in the tuber can initiate an outbreak of the disease and that oospores have not yet been shown to give rise to the first outbreak.

Regarding, therefore, mycelium in the tuber as the over-wintering stage infection of a shoot just beginning to grow can take place by the growth of mycelium from a nearby lesion in the tuber. If the shoot is attacked early in its growth, dwarfing will result so that, when normal shoots are 8 inches tall, the infected shoots may be only just above ground. Sheltered by the foliage of healthy stems and given satisfactory temperature and moisture conditions, conidiophores will grow out through stomata in the dwarfed shoot and conidia

will be abstricted. Not many are needed to initiate the outbreak. A conidium germinates in a short time in a thin layer of water on the leaf giving rise to 8 zoospores. These are motile for perhaps an hour, then they come to rest, germinate by a germ tube and infect the leaf. Under moist summer conditions this is repeated approximately in 10 days, but the period elapsing between successive sporulations increases with decreasing humidity.

Tuber Infection

Some spores are washed through interstices of the soil to the tubers in the upper part of the hill, and if the skin of the potato is still immature, infection may easily occur. Early infection may cause total rotting of the tuber, while later infection may only give rise to small lesions. It is most important to remember that late attacks of blight will mean a plentiful supply of conidia on surface soil and plant parts at digging time and most tuber infection occurs at this stage.

Control Measures

1. Selection of sound seed tubers.
2. Thorough spraying with Bordeaux from July to mid-September.
3. Hilling of potatoes to protect upper potatoes in hills from tuber infection.
4. Removal of tops two weeks before harvesting to prevent tuber infection.

GROUP 5

Disease Caused by an Ascomycete—Wilt and Stem-Rot or Stalk Disease

Sclerotial diseases of the potato have been reported from many countries within recent years. That known as "stalk disease" caused by *Sclerotinia Sclerotiorum* is common in the West of Ireland and in the northern damper parts of England and Scotland. Growers believe that it is the most serious potato disease in these districts next to Late Blight. A similar disease caused by the same fungus attacks tomato, artichoke, sunflower, bean, squash, cucumber, carrot and turnips (Cotton, A.D.) in Great Britain. Bisby has reported a sclerotial disease of sunflower from Manitoba which is common also in Quebec and elsewhere. Mac-Alpine found a sclerotial disease of potato in Australia, which he attributed to *S. sclerotiorum*, Carpenter one in Hawaii caused by *S. Rolfsii*, and Pole Evans reports one from South Africa. During the summer of 1921 Mr. O. W. Lachaine found 10 per cent infection of a 4 acre field of potatoes in Restigouche County, New Brunswick, and four other fields of 3 or 4 acres had from 1 per cent to 2 per cent infection. The photograph (Fig.

11) is from Lachaine's material. Happily the disease according to present indications does not appear to be serious on potatoes in this country although more work must be done on it to determine this authoritatively.

Symptoms

The first signs of the disease are patches of whitish mycelium on the outside of the potato stem at, or just above, ground level. If the weather is humid profuse mycelial growth occurs with the later development of external sclerotia. At first these are whitish, turning black and finally falling to the ground. At the same time the mycelium gradually penetrates the inner tissues reaching to the pith. In the pith rapid growth takes place with the formation of internal sclerotia. These are well shown in Fig. 11. If moist conditions prevail, the stem will by this time have wilted and in many cases have fallen over, collapsing at the affected part. On the other hand dry weather will tend to check external development and only internal sclerotia may be found. The outer cortical tissues will be killed and discoloration will be prominent on the stem but it will not fall over. Nor may wilting occur but in all cases there will be a yellowing of the leaves.

Lachaine informs me that the symptoms were first noticed in New Brunswick on August 24th, 1921, at a point about half an inch above ground on the stems. A blackish zone extended from this point upward for 3 to 5 inches giving somewhat the appearance of "black-leg." By rubbing, the cortical tissues were easily removed and on September 16th (3 weeks later) the outer necrotic tissues were dried out while the leaves were yellowed. Above and below the necrotic area the stem tissues were still green. On splitting open the affected stems abundant sclerotia were found in the place of the pith.

Fig. 9—Sclerotial disease of potato. Stems opened to expose sclerotia. Cortical tissues disintegrated.

Life History of the Organism

Sclerotia remain dormant in the soil until early summer when they may germinate, giving rise to apothecia bearing ascospores. The ascopores are discharged and infect the older leaves of the stem in the lowest axils.

The sclerotia may also live over winter in the soil and germinate by mycelium which can infect the plants.

In England and Ireland the organism is known as *Sclerotinia sclerotiorum*, but for the sclerotinia found by Lachaine in New Brunswick, no definite name can yet be given, although it appears to be *S. libertiana*.

Control

The only satisfactory means of control are crop rotation so that susceptible plants are not available to the fungus and careful removal and destruction of diseased plant parts.

In England, Cotton finds that late planting has proved successful since fewer old leaves are available at the time of spore discharge.

GROUP 6

Disease Caused by a Basidiomycete.—Dry Stem-Rot and Black Scurf

This disease is known under a variety of common names of which the chief are:—dry stem-rot, black scurf, black scab, russet scab, Rhizoctonia disease, little potato, acrial potato, rosette, black speck scab and collar fungus.

The first description of Rhizoctonia was given by Duhamel in 1728 as causing a disease of saffron in France. De Candolle in 1815 gave the fungus the name *Rhizoctonia* when he discovered a similar disease on lucern. In 1851 the Tulasne brothers classified all the then known rhizoctonias as *R. violacea* but Kuhn in 1858 described a species on potato which he named *R. solani*. Webber (1890) first reported the fungus in America and in 1901 Duggar and Stewart (Bull. 186, N.Y.) gave a list of hosts attacked by Rhizoctonia. It is now known to occur generally in the United States and Canada and is reported from the West Indies, India, Australia and South America. The perfect stage was found by Rolfs in 1903 on potato stems and described as *Corticium vagum B. & C. var solani* by Burt.

Other Hosts

The complete list of other hosts would be too long to include here but mention may be made of tomato, bean, lettuce, carrot, cabbage, pea, pumpkin, beet, carnation and pansy.

Symptoms

These vary considerably with climatic conditions, age of the plant at infection, and the soil type. The sclerotial stage is very common on tubers where many black sclerotia of varying shape and size (but usually small) are found on the surface. They do not cause any apparent injury since they are superficial.

Frequently, however, the skin is more or less cracked and russetted and a still more advanced stage may give rise to scabbing. In this condition drying out in storage or the entry of secondary organisms is facilitated.

Fig. 10—Dry stem-rot of potato. Note that lesions occur about at ground level and that the plant may branch out again from below. (After Bull. 85, Mich.)

If the soil is wet or poorly drained and the temperature high, severe infection may completely cut off the young shoots before they appear above ground and this in some measure accounts for misses in the field. Sometimes side branches may grow up from below the lesion on dead haulms (Fig. 12), but such branches are weak and spindling, with yellowish leaves. Older plants severely attacked just below ground wilt and die off rapidly. Slight attacks will produce lesions on the stem tending to girdle it and in this case the tops are more or less dwarfed and yellowed. As the fungus gradually encircles the stem and penetrates the tissues, water supply is cut off increasingly so that there is a shortening of upper internodes and dwarfing of leaves which gives rise to "rosette top". At the same time the leaves may be slightly wilted and yellowish to reddish green in color and curled. This curling is easily distinguished from the crisp condition in true Leafroll.

When the stem is attacked at the time of early tuber formation so that ample food is being elaborated, the girdling of the stem cuts off the translocation of food to the stolons. This disturbance in direction of translocation causes the development of aerial tubers in the axils of leaves. I found many such cases in France during the war and in all cases where aerial tubers were formed there was a closely matted weft of mycelial growth around the stem for about two and a half inches above ground level. That the formation of aerial tubers is not due to root injury, but changed translocation of elaborated food, can be

shown by cutting away carefully the developing stolons around the base of the stem when aerial tubers begin to develop.

On the other hand, if root infection occurs the metabolism of the plant as a whole is affected, the plant is definitely dwarfed and the leaves cannot function to a normal extent so that the potato tubers formed, if any, are small, giving the condition known as "little potato".

Life History of the Organism

Usually the mycelium does not give rise to the sporiferous stage but late in the season forms the small compact blackish sclerotia on the surface of the tubers, If the sporiferous stage is developed it occurs on the weft of mycelium around the base of the stem just above ground. Here the spores are borne on basidia, four spores, measuring 6-8 by 9-14 microns, each on a short sterigma for each basidium. They germinate and cause new infections in the field. The mycelium can grow through or over the soil and in one case north of Arras, France, the writer found that the mycelium grew, during two months of a cool, moist summer, ten yards along a row from the originally infected potato. Cultivation between the rows prevented its lateral spread.

Control

Since *Rhizoctonia* prefers heavy, moist soils, drainage and the avoidance of heavy soils difficult to drain is important. If the soil is heavily infected it is inadvisable to plant potatoes. With ordinary soils seed tuber disinfection should be practised. In this connection Howitt at Guelph is doing some interesting work on control by corrosive sublimate. His work for 1920 shows that treating tubers with sclerotia on them for 2 hours in corrosive sublimate, 1 in 500 gave perfect control, while treatment for 2 hours in a solution 1 in 1,000 reduced disfigured tubers to 14 per cent. The experiments are still in progress.

GROUP 7

Diseases caused by Fungi Imperfecti (Adelomycetes or Deuteromycetes)

(a) Early Blight

This disease is common in years when Late Blight is not serious and while it does not attack the tubers the yield is reduced because of leaf injury. The amount of injury depends upon the season and it is greatest when hot spells alternate with moist weather. In such cases losses in yield may reach as high as 25 per cent, unless spraying is consistently practised. The disease is caused by a fungus known as *Alternaria solani* (E. & M.) J. and G.

Symptoms

During the season the leaves are the only parts attacked. The first sign of the disease is a small yellowish spot with a slightly watersoaked margin. The spot enlarges until it is from 1-8 to 1-4 of an inch in diameter and variations in the growth rate of the fungus give rise to concentric markings in the spots. The whole becomes dried out and brownish-black and it frequently happens that the central part of the lesion falls out giving rise to a modified "shot-hole" effect. When the disease is severe owing to suitable infection conditions several spots may coalesce. Under these circumstances the foliage is considerably reduced and at times very few mature leaflets will have any chlorophyll-bearing tissue with which to function in manufacturing food for plant growth and tuber development. Persistence of these conditions will involve the premature death of the vines.

The stems are not affected until late in the season and it is in debris from vines and leaves that the fungus overwinters.

Life History

The fungus may overwinter as mycelium in old lesions in plant debris or as spores but there is no known perfect stage. Under moist conditions, spores which have overwintered or have developed from over-wintered mycelium, infect leaves causing the characteristic spots. On these dead spots the fungus produces many conidiophores bearing racquet-shaped, multicellular spores. These, when washed or blown to other leaflets, germinate rapidly if moisture be present and so the disease is spread throughout the season.

Other Hosts

Alternaria solani may also attack the tomato.

Control

The only method of control is consistent spraying with Bordeaux as for Late Blight.

(b) Wilt or Fusariose

Luckily this disease, caused by *Fusarium oxysporum* Schlect, is not of serious economic importance here since the causal organism is best suited to sandy loam and a hot growing season. It is common in Pennsylvania, Ohio, Michigan, Indiana, South Dakota, etc., and it is sometimes severe in southeastern New York. The fungus is to be found in our sandy-loam soils and potatoes are attacked but wilting to any marked extent does not often occur.

Symptoms

In early stages of the disease the plant shows rolled, slightly yellowed foliage. The rolling can be differentiated from that in "Leafroll" because the leaves are not stiff and inclined to brittleness as in the latter disease. If the attack is slight rolling and yellowing of the leaves combined with a dwarfing of the plant may be the only symptoms until late in the season, when such plants die down prematurely. If the invading organism develops more rapidly the lowest leaves yellow and fall and there is a tendency to "rosette-top" quite similar to that in the Rhizoctonia disease. Given optimum conditions for the fungus the vines lose their lower leaves and wilt. In very severe cases a lesion may be obvious just below ground level but, as a rule, it is only on cutting through the stem that one can see the browned condition of the vascular tissues. Some times only one or two haulms in a hill are affected but generally the whole plant shows the symptoms.

An inspection of the root system proves that root tips and feeding roots are rotted off and larger roots when sectioned are seen to have browned vascular tissues. Lesions occur on the stolons owing to attacks from the outside. The organism can grow from the affected stem or stolon into the vascular tissues of the tuber and here it gives rise to "net-necrosis". The necrosis of the vascular tissues of the tubers varies from slight, when it only penetrates a quarter of an inch from the stem, to severe when it may extend from the stem-end over half way through the tuber. In the latter case tuber rot may occur if moisture and temperature conditions during storage are suitable. In the former such tubers used for seed develop "spindling" sprouts.

Sources of Infection

There are two sources of infection:—(1) the soil and (2) diseased seed-tubers. In the first case wilting does not usually occur until late in the season if it occurs at all, and this is the condition generally here. In the second case, either the plants are so spindling that they cannot grow or wilting may occur earlier in the season when tubers are about half grown.

Resistant varieties

Little is yet known of varieties actually resistant but it is important to notice that early potatoes escape the disease. Thus Irish Cobbler tubers are fairly mature by the time Fusariose becomes prevalent while Green Mountain tubers are just forming.

Control

1. If the soil is known to be infested crop rotation must be practised and if the infestation is severe a long rotation of five or more years is necessary.
2. Tubers should be selected for soundness. All germinated tubers show-

ing a tendency to "spindling sprout" should be discarded. If the tubers have not been sprouted the stem-end of suspicious tubers can be clipped and those with net-necrosis discarded, or the stem-end half only discarded if the bud end is healthy.

3. Plant disease-escaping varieties, i,e. early types.

(c) Common Scab

In Europe, Africa, Australasia, and North America common scab occurs probably everywhere the potato is grown. The disease is caused by a fungus closely related to the higher bacteria and known as *Actinomyces scabies* (Thax.) Gussow. It is often present to such an extent as to prohibit potato culture but usually the chief loss comes from depreciation in the sale value of the tubers. Estimates show that there is a variation from 5 p. c. to 75 pc. of the crop which is unfit for sale.

Symptoms

This is a tuber disease and the symptoms vary from shallow, rough pittings if the attack occurred when the tubers were nearly mature, to deep rough pittings with furrows and cracks if the potatoes were infected when young. At first the scab appears as a minute red-brown spot. It gradually extends outward, becomes irregularly corky and deeper brown in color. Scab mites, white grub and wire worms enlarge and deepen the injury, making the tubers still less valuable.

Life History of the Organism

The fungus lives overwinter in the scab spots on the tubers or in the soil. In the soil it may persist for many years and in that case long rotation is not sufficient but soil treatment must be considered. Alkaline soils favour the fungus and acid soils check it. Thus the addition of lime, stable manure, potash or ashes to soil is dangerous when it is known that the scab organism is present.

Other Hosts

Turnips, beets and mangels are susceptible to attack by this organism and therefore these crops cannot be used in a rotation.

Varietal Susceptibility

Irish Cobbler, Sir Walter Raleigh and Carmen among others are fairly resistant to scab.

Control

Two essentials are clean seed tubers and clean soil. If the soil is clean great care should be taken regarding the seed tubers and when there is any doubt, disinfection should be thoroughly performed. Even in the case of infected soil,

it is essential that clean seed tubers be used since otherwise the infestation is being increased. Long continued investigations are demonstrating the value of sulphur as a medium for soil treatment. Martin in 1921 found that only 8.9 p.c. of clean tubers developed in infested, untreated soil but when 600 lbs. per acre of finely ground sulphur were applied there were 33.5 p.c. clean tubers and when 600 lbs of inoculated sulphur were used per acre the clean tubers reached 50.9 per cent. This, it is to be remembered, is in soil severely infested with *Actimomyces scabies*. In some soils 600 lbs. of sulphur per acre might be disadvantageous while 300 lbs. would be satisfactory. By inoculated sulphur is meant sulphur having mixed with it soil containing sulphur oxidising bacteria.

(d) **Skin spot** (*Oospora pustulans*)

Reference has already been made to the fact that skin-spot has been shown by Shapovalov to be a stage of Powdery scab.

(e) **Silver scurf**

Harz in 1871 first described this disease when it occurred in Austria and since then it has been found in Germany, Great Britain, Ireland and North America. It is caused by a fungus named *Spondylocladium atrovirens* Harz.

Symptoms

In its early stages silver scurf, under moist conditions, causes olive black patches to appear on the surface of the potato. These dingy patches are the conidiophores and spores of the fungus. The spots may be small, or may cover an area half an inch or more in diameter. Later in the season the surface layers are slightly raised by the abundant growth of mycelium in the cells below and at this time small, black, superficial sclerotia are formed. When washed the raised areas appear whitish or silvery, giving rise to the name "Silver scurf". Still later in the season these raised areas gradually become depressed owing to the death and collapse of infected cells. If the season is moist enough for rapid fungus growth the areas increase in extent until in severe infections the whole surface of the tuber is involved and the fungus penetrates more deeply into the tissues. As a result it is not unusual to find tubers which are entirely discolored and shrunken. Surface layers with sclerotia slough off and thus infect the soil.

Life History

The fungus overwinters as sclerotia which are very minute. These may be on the surface of the potato or in the cells of the outer layers or in debris sloughed off into the soil. How long such sclerotia may live in a dormant condition is doubtful, but given moist, warm environment they germinate readily by conidiophores. Vegetative development is rapid and from spore to spore occupies a period of only four or five days under optimum conditions. The conidiophores are erect, dark-brown, and tall (120 microns) and the spores are borne in whorls on the upper parts of the conidiophores. The spores are dark

brown, five to seven celled and apparently quite resistant to adverse conditions. It is thus possible that spores developed later in the season may over winter.

Control

The ordinary methods of seed-tuber disinfection do not control this disease and the only suggestion at present efficacious is that of tuber selection.

(f) Dry Rot of Tubers

Heavy losses in stored potatoes sometimes occur in those years when Late Blight does not appear to be an important factor. Such losses are mainly due to tuber rots caused by species of *Fusarium*. It is difficult accurately to ascertain the extent of such losses but they take a heavy annual toll from growers and dealers.

Symptoms

Fig. 11—Original photograph from material collected at Macdonald College, September 21st, 1921. The minute sclerotia on the inside and outside of the affected stems are shown.

The rot usually starts from a wound which penetrates the tissues or which may be merely an abrasion of the skin. At first the affected tissues are firm and cheesy and the fungus produces white or pink tufts of mycelium, conidiophores and conidia on the surface. As the diseased part increases in area and depth the tissues dry out, shrivel and eventually become quite hard. Under warm, humid conditions the rot develops more rapidly and is softer, at first, but finally the tuber becomes shrunken and hard. If *Fusarium* species only are present there is no foul odour but usually bacteria are to be found associated and hence the rot may be softer and malodorous.

Causal organisms

Fusarium discolor sulphureum is probably the chief cause of dry rot but *F. oxysporum* may penetrate so far into the tuber tissues that it also gives rise to storage rot. Other species of *Fusarium* occasionally cause similar rots but they are not usually so serious.

Relation to Late Blight Rot

The rot caused by *Phytophthora infestans* when severe is seen at digging time and the heaviest losses begin to show soon thereafter in storage but *Fusarium* rots inflict heaviest losses in the later storage period. It is obvious, however, that small lesions caused by *P. infestans* are eminently suitable as points of entrance for *Fusaria* and infection by *Fusaria* commonly occurs. The rot is then not "dry" as in the case of infection by *Fusarium* alone.

A feature of importance is the amount of rot in storage which occurs in certain years even after consistent spraying with Bordeaux is practised. Murphy (Ottawa Bull. 44) has mentioned this and I have had many request for information from Quebec farmers. During a warm wet autumn the sprayed plants remain green and continue to grow well on to harvest. At digging time, the tops are still green and under such conditions some Late Blight is almost sure to be present. Spores fall on moist tubers and infection may occur which does not manifest itself until later in storage. Even if no Late Blight be present, the tubers are immature so far as their skins are concerned and therefore are easily injured. Through these injuries *Fusaria* enter and in the spring there is the likelihood of heavy loss from dry rot. It would probably be better to cut the tops some seven to ten days before digging to remedy this, and experiments are under way to determine the efficacy and economy of such a procedure.

Storage Conditions

Moist warm storage is suitable for the rapid spread of dry rot (and other storage rots) and it is therefore important to be able to ventilate well and to maintain a temperature about 35° F., or slightly lower so long as the freezing point is not reached.

Fusaria can live over the summer on refuse in the corners and on the walls of bins, and clean bins are essential to safety.

Effect on plants

If infected tubers are used for planting the rot may continue so that no plant develops or the shoots are weak and spindling. It is entirely inadvisable to use even doubtful seed.

Control

1. Avoid injury to tubers as much as possible.
2. Use cleaned and disinfected bins.
3. Keep the storage places cool (35° F.), well-ventilated, and dry.
4. Avoid digging tubers for storage with immature skins.
5. Plant healthy seed tubers.

(f) Net-necrosis

The term "net-necrosis" was first used by Orton in 1914 to describe a discoloration of the vascular tissues of the tubers. The color varies from brownish to black and it may appear in the stem-end only or extend throughout the tuber. There are now three accepted types of net-necrosis, viz:—*Frost net-necrosis, Fusarium net-necrosis* and *Leafroll net necrosis.* It is also suggested that a net-necrosis may be caused by adverse soil or growing conditions.

In any of these cases it is inadvisable to use such tubers for seed purposes since they will develop spindling plants.

The net-necrosis under consideration is that which is the result of Fusarium infection, usually *F. oxysporum.*

Symptoms

The discoloration of the vascular tissues varies from a slight browning at the extreme stem-end to an intense darkening two-thirds or more through the tuber. In very severe cases the discoloration may extend to the bud-end but usually the distal half of the tuber is free from any symptoms. There are all gradations between these extremes. Slices cut across the stem-end show that not only the vascular elements of the ring but also the secondary vascular strands in the cortex and medulla are affected.

On cutting successive slices it is seen that the discoloration becomes less intense as the bud-end is approached and that it is more confined to the vascular ring and cortex and later to the ring only. Gradually the discoloration disappears and slight water-soaking in the vascular ring is the last symptom towards the bud-end. By paring the tuber down to the vascular ring the net work of discolored tissues is easily seen, Externally, affected tubers appear to be sound, but occasionally, the blackened bundles at the stem-end may show thro ıgh the skin.

Effect on Plants

Fig. 12 —Photograph of half Petri dish showing sclerotia developed in artifiçial culture on dextrose agar.

Such tubers used for seed purposes give rise to spindling plants, the weakening of the plant depending on the extent of vascular necrosis. The basal buds are most affected and the apical buds least.

Control

1. Plant only healthy seed. If in doubt slice off the stem-end and discard tubers showing strong discoloration.

2. Sprout tubers before planting and discard those with weakly sprouts, or if apical sprouts are strong while basal sprouts are spindling cut off and discard the stem-end.

3. It is probable that dusting the cut surface with finely ground sulphur would be helpful.

(h) **Black dot disease**

Ducomet in France, in 1908, reported the occurrence for the first time of a disease which he called "dartrose" caused by *Vermicularia varians*. McAlpine some two years later found it in Victoria, Australia, and Doidge more recently in South Africa. McAlpine named it "Black dot disease", an excellent descriptive name.

In the late summer and autumn of 1921 I discovered what appears to be the same disease at Macdonald College in Quebec. This is the first time its appearance is noted on this continent and a full description will be given later elsewhere.

Symptoms

The first symptom is a slight yellowing of the foliage which begins at the tips of leaflets and gradually involves the whole leaves. It may or may not be accompanied by dwarfing of the plant depending upon the earliness and severity of the infection. The yellowing will show early in the season on plants heavily infected but usually it is a midsummer symptom. The yellowing is followed by browning and withering of the leaves and if moist conditions prevail minute black sclerotia will develop on the surface. At this time the lower stem parts are covered with sclerotia and gradually the stem darkens and becomes brittle. On opening the stem the pith is seen to be disorganized and sclerotia line the inside walls of the vascular cylinder. Figure 11 indicates the size and number of the sclerotia both on the inside and outside of the stem. Roots and rhizomes are attacked and the tubers are covered with the minute sclerotia. It apparently does not cause serious damage to the tuber since the mycelium is confined to the superficial tissues and the sclerotia are developed on the surface or are slightly erumpent.

Mycelium is to be found throughout the stem and leaf tissues of yellowed plants which have sclerotia on the leaves.

The organism

Ducomet describes the sclerotia as astomic pycnidia 75—150 microns in diameter with setæ 100 to 130 microns long and at least biseptate. The spores are slightly curved and 18-22 microns by 2.5 to 3 microns. In my cultures the spores are slightly smaller and the setæ longer and no pycnidia have been found. McAlpine also states that he has found no pycnidia in Australia. More detailed discussion will appear elsewhere.

Figure 12 illustrates the development of sclerotia in a Petri dish culture on dextrose agar.

Other Hosts

Ducomet states that this organism is parasitic on Tomato and *Physalis peruviana*. I have artificially infected tomato but have not yet tried *Physalis sp.*

Control

This disease is serious only in that it weakens plants and therefore reduces the crop. Exactly to what extent it is of economic imortance it is as yet impossible to state.

McAlpine advocates burning the haulms of diseased plants and selecting clean tubers for planting.

GROUP 8

"Physiological" diseases

(a) Black heart

As the name indicates, the symptoms of black heart are confined usually to the medullary region. The blackened tissues are irregular in outline and almost always elongated from stem to bud and with branches extending towards the buds. Occasionally there may be large black spots scattered irregularly through the flesh of the tuber and sometimes the vascular tissues are blackened. Surface discoloration of the tuber occurs in cases of insufficient aeration but usually no surface symptoms are evident.

There are two conditions which bring about black heart. The first is overheating and this is a shipping trouble. Among potatoes shipped during the winter in stove-heated cars those in the vicinity of the stove are frequently found to be badly affected with black heart. The experiments of Bartholomew in 1913 showed that heating tubers to 100-113° F. for 14-18 hours brought about changes in the respiration rate of the tubers so that in the overheated environment more oxygen is demanded than is available. The innermost tissues are the first to be affected by the insufficient oxygenation and they become necrotic and brown to black in colour. Gradually the dead cells dry out becoming shrunken, tough and black.

The second condition was demonstrated by Stewart and Mix at the N. Y. Geneva Station. They showed that black heart occurs at low temperatures if the oxygen supply is markedly deficient. Tubers confined with a volume of air equal to the volume of potatoes required up to 40 days for black heart to develop at 40° F.

Whether affected tubers sprout or not depends upon the extent of the collapsed tissues and upon whether the injury is due to insufficient oxygenation at high or low temperatures. Usually the latter require a longer time for sprouting but if no surface injury is present and the buds sprout well there is no harm in using such tubers for seed. It is obviously unwise to use tubers with surface lesions for seed since the lesions will become breeding grounds for fungi and bacteria.

Control

It must be remembered that potatoes stored at high temperatures and for a long period require more ventilation than those stored at lower temperatures or for short periods.

1. Potatoes should not be stored more than six feet in depth at temperatures below 45° F. for a lenghhy period of time. At temperatures of 50° F. to 70° F. they should not be piled more than 3 ft. deep if they are to be kept longer than a month.

2. Small potato pits do not need extra ventilation but the tubers should be protected from frost.

(b) **Frost necrosis**

In Canada, as in the northern tier of states of our neighbour, the main crop is in constant danger of exposure to freezing temperatures from the time of harvest to planting or to retail sale. There are two types of frost injury, viz:—that in which complete freezing occurs and that in which no superficial symptoms are noticeable. In the first case freezing is due to exposure to a very low temperature or to prolonged freezing at a somewhat higher temperature. The tubers are frozen solid and the tissues collapse on thawing. The soft, wet condition resulting is easily recognized.

The second type is due to exposure to temperatures just below the freezing point or to a very low temperature for a short time. In this case, the tuber is never frozen completely but certain tissues only are affected. Upon exposure to ordinary storage temperatures the affected tissues become necrotic and are blackish in colour after being exposed to oxidation in the air. The necrosis is of three general types, viz., net, ring, and blotch.

In "net" necrosis there is a general blackening of the finer vascular elements extending from the vascular ring into the medulla and cortex.

A more pronounced blackening in the vascular ring and adjacent tissues gives the "ring" type of frost necrosis. This is often most apparent at the stem-end.

When the necrotic areas are larger and less defined we have the "blotch" type and this is often found in the cortical tissues.

Frost injury before or during harvest may give rise to any of these types or modifications of them, but, as a rule, the ring type predominates if exposure

is short since vascular tissues are more sensitive than parenchymatous, while the blotch type is common with long exposures to chilling temperatures.

(c) **Net necrosis** or **Vascular discoloration**

In discussing Leafroll, Fusariose, and Frost necrosis it was pointed out that the term "net-necrosis" is applicable to any of these tuber troubles if the delicate vascular network is discolored.

In discussing vascular discoloration Edson in 1920 says: "A popular impression has prevailed that any except the most superficial stem-end discoloration might be taken as a trustworthy indication of the presence of Fusarium, or, at least, that the stock was grown on vines affected with Fusarium or Verticillium. Somewhat extensive preliminary observations and cultural studies, made by the writer both at the time of harvest and during or at the close of the rest period, on stock grown in sections where Fusarium blight and wilt do not occur, as well as in sections where they are known to be general, show that, while Fusarium and Verticillium undoubtedly do cause vascular discoloration of potato tubers, discoloration can not be accepted as proof of the presence of Fusarium or, indeed, of any other organism, nor can the absence of discoloration be confidently accepted as proof of the sterility of the vessels near the stolon attachment. There seems to be reason to think that vascular necrosis may often arise from purely physiological causes and that it need not necessarily be seriously abnormal, though frequently it is."

This author found that out of 3,042 planting from discolored tissues 1,352 gave no growth.

(d) **Internal brown spot**

In this disease brown spots are scattered through the flesh of the tuber and are not confined to the vascular ring. The spots consist of dead brown cells surrounded in many cases by cork cells. It is possibly something like stippen in apples and is associated with unfavourable soil moisture conditions at a critical period in the growth of the tuber.

(e) **Spindling sprout**

Weak spindling sprouts are likely to develop from tubers affected by mosaic, leafroll, fusarium necrosis, etc., and in all instances such weaklings are best eliminated from the crop. It is also found that potatoes grown under unfavourable soil or climatic conditions tend to give rise to spindling sprouts when used for seed. Similarly the same strain grown year after year will gradually lose vigour and "run out" resulting in weak progeny. It is advisable to sprout potatoes before planting and to discard those with thin, straggling, spindling sprouts.

(f) Hollow heart.

This condition occurs as a result of the too rapid growth of the tubers. Some varieties, such as the Rural New Yorker, when grown in rich soil, frequently develop hollow heart. The tissues surrounding the irregular space in the heart of the tuber are brown and lined with a corky layer. The trouble is not serious from a pathological point of view.

(g) Arsenical injury

This is not serious when ordinary precautions are observed. Arsenic oxide is the base of any arsenical spray used in controlling chewing insects and its use alone would cause severe burning to the foliage. It is therefore necessary to use it in a combined form such as Paris green, lead arsenate, calcium arsenate, etc. The arsenate is better used in combination with Bordeaux, so that sufficient lime is present to prevent burning of the foliage. Burning occurs where insects have made injuries and in the axils and margins of leaves where the insecticide is likely to be held in quantity. The use of a finer spray from high pressure nozzles will usually prevent such accumulations of material on the plant.

General considerations in control

1. Control of potato diseases by the grower involves as a first essential that the grower know the diseases which have to be controlled. Every grower of potatoes on a large scale ought to familiarize himself with symptoms and with the major points in the life history of the causal organism if such exists. To do the right thing at the correct time necessitates accurate knowledge. Information can always be obtained from Macdonald College in Quebec, from the Ontario Agricultural College in Ontario, from other agricultural colleges throughout the Dominion and also from Provincial and Dominion Departments of Agriculture. No grower need lack technical help to-day in this respect.

2. Next to a knowledge of the diseases to be controlled and how to control them, the most important point is to know thoroughly the variety or varieties most suitable for the locality and the market. It is best to grow only one or two varieties and to know these so that "off varieties" can easily be detected and rogued from the seed plot. Grow a seed plot every year and select hills for freedom from disease and for yield and type. In arranging the seed plot choose clean land, prepare it well, practise deep plowing and rotation with legumes and cultivate the potatoes thoroughly.

3. As to the seed tubers themselves the selection of thoroughly clean, sound tubers is a prime requisite. Too many growers still plant scab, black

leg, blight, etc. and expect to get potatoes. If it is impossible to obtain first class, clean seed the next best thing is to treat what is available.

4. For seed tuber treatment two chemicals are availabie :—mercury bichloride, which is a deadly poison, and formaldehyde which is also a poison, but which warns one by the gas given off.

Mercury bichloride or corrosive sublimate treatment

Soak the seed tubers in a solution made of 4 ozs. of mercury bichloride in 30 gallons of water for half an hour. If Black scurf is present treatment for a longer period is advisable acording to the work of Howitt at Guelph (see p. 91). The addition of one ounce of mercury bichloride to the 30 gallons ot water after each sack has been treated will keep the solution up to strength. If larger quantities are to be treated vats should be used so that the tubers can be handled in crates. It is important to remember that with corrosive sublimate (mercury bichloride) no metal vessel can be used. Treated tubers are poisonous to stock and man. The corrosive sublimate can first be dissolved in 2 gallons of hot water and added to 28 gallons of cold, since it is not easily soluble in cold water.

Formaldehyde treatment

1. Soak seed tubers for 15 minutes in a solution of formaldehyde made by adding 1 pint (or 1 lb.) of concentrated formaldehyde (commercial of 40%) to 30 gallons of water.

2. A method recently tested by Melhus is recommended if the grower can arrange a tank in which formaldehyde solution of double the above strength is heated to 118° to 122° F. In this case the tubers are soaked for two minutes at this temperature and then covered for an hour before cutting.

5. If it is not convenient to plant immediately after the completion of seed tuber treatment, care must be taken that the treated tubers are not placed in sacks or containers which have not been disinfected.

6. When cutting the tubers discard all rotted stock and also those tubers showing browning or blackening in the vascular ring at the stem end. It may happen that the discarded tuber would give a healthy plant but the chances are against it and "safety first" is a wise saw.

7. During the growing season give the plants good cultivation.

8. Spray thoroughly with Bordeaux mixture from the time the plants are eight inches high. Make the applications about every two weeks depending upon the weather. If the weather is moist and warm and plants are developing new leaves very rapidly they must be covered with spray and hence spraying may have to be done every ten days and perhaps later during a drier

spell at longer intervals like 2½ weeks. Spray before a wet spell and use a fine spray which will cover *both* sides of the leaves. Dusting is as good as spraying for potatoes in most localities. To control potato-chewing insects it is necessary to add calcium arsenate or lead arsenate to the spray or dust. It is not necessary here to deal with the preparation of Bordeaux mixture or dust, but any grower desiring information will be gladly accommodated if he will write to Macdonald College.

9. Finally greater care must be taken in digging, handling and storing potatoes. It is unfortunate that an excellent yield is sometimes spoiled in its last stages by bad handling.

SCLEROTIAL DISEASE OF THE POTATO

By O. W. Lachaine, B.S.A.

Sclerotial diseases of the potato have been reported from many countries within recent years. That known as "stalk disease" caused by *Sclerotinia sclerotiorum* is common in the West of Ireland and in the northern damper parts of England and Scotland. Growers believe that it is the most serious potato disease in these districts next to "Late Blight". A similar disease caused by the same fungus attacks tomato, artichoke, bean, cucumber, carrot, turnip, corn, pea, cabbage, cauliflower, hemp and chicory (Cotton, A. D.) in England. Bisby has reported a sclerotial disease of sunflower from Manitoba which is common also in Quebec and elsewhere. MacAlpine found a sclerotia disease of potato in Australia, which he attributed to *S. sclerotiorum;* Carpenter one in Hawaii caused by *S. Rolfsii*, and Pole Evans reports one from South Africa. During the summer of 1921 the writer found 10 per cent infection of a 4 acre field of potatoes in Restigouche County, New Brunswick, and four other fields of 3 or 4 acres had from 1 per cent to 2 per cent infection.

Symptoms

The first symptom noticed by the writer, August 24, 1921, was a blackish zone extending from the surface of the soil to about 5 inches in height giving it somewhat the appearance of "blackleg". By rubbing, the cortical tissues were easily removed. Three weeks later, on September 16th, the outer necrotic tissues were dried out while the leaves were yellowed. Above and below the necrotic area the stem tissues were still green. On splitting open

the affected stems abundant sclerotia were found in the place of the pith. These are well shown in Fig. 1-A.

These symptoms are not the first, while conducting experiments in the green house, with potato and tomato plants, I have discovered their precedents.

The first signs of the disease are patches of whitish mycelium on the outside of the potato or tomato stem at the point of infection at the surface of the soil, where the natural infection ordinarily takes place. If the weather is humid profuse mycelial growth occurs with the later development of external sclerotia. At first these are whitish, turning black and finally falling to the ground. At the same time the mycelium gradually penetrates the inner tissues reaching to the pith. In the pith rapid growth takes place with the formation of internal sclerotia.

Fig. 1.—Sclerotia in pith of potato stem.

Cultural Characteristies

The sclerotia, after being frozen for a month, sterilized in 1:1000 solution of mercuric chloride and washed in sterile water, develop profuse mycelium but in no case was an apothecium observed.

The mycelium develops more rapidly on sterile carrot than on potato or oat-meal agar. The carrots were first covered with a white mass of mycelium, which gradually turns brown and then black, forming a solid mass of sclerotia on the surface, shown in Fig. 2.

On oat meal and potato agar the rapidity and the mode of growth of the mycelium are the same. The mycelium ordinarily grows on the surface of the agar, but in few exception it is slightly upright. In every case there is a large number of small sclerotia (Fig. 3 and 4) although on the carrot the sclerotia are large.

Inoculation

Potato plants and one of tomato were inoculated on the stem a little above the surface of the soil with mycelium obtained by growing sclerotia, from the interior of a potato stem, on a piece of sterile carrot.

Fig. 2.—Sclerotial disease of potato. Solid sclerotial growth on surface of carrot.

The infection on the tomato stem was more rapid than that on the potato stems. On the tomato the mycelium grew and the cortical tissues were destroyed 2 inches above soil level and the plant wilted. Fig. 5. (A indicates upper limit of cortical tissue destroyed.)

At present one of the inoculated potato stems has tissues for ¾ of an inch in height and half of the circumference of the stem destroyed, on another,

Fig. 3—Small sclerotia on potato agar.

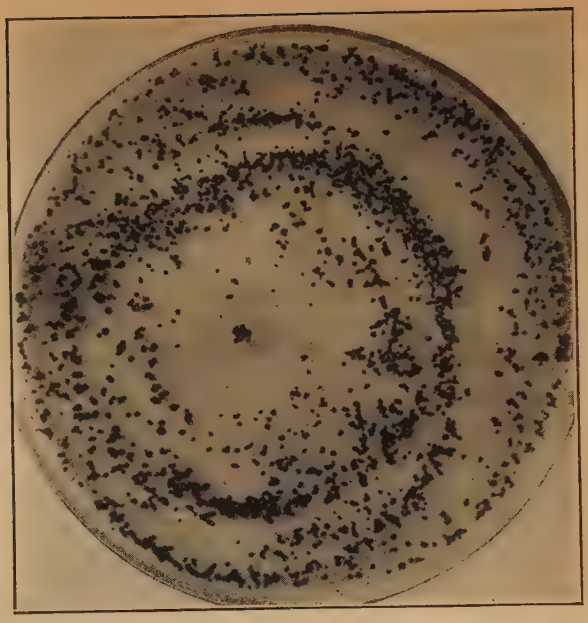

Fig. 4.—Small sclerotia on potato agar.

Fig. 5.—Tomato inoculated at soil level. Note disintegrated cortex up to A.

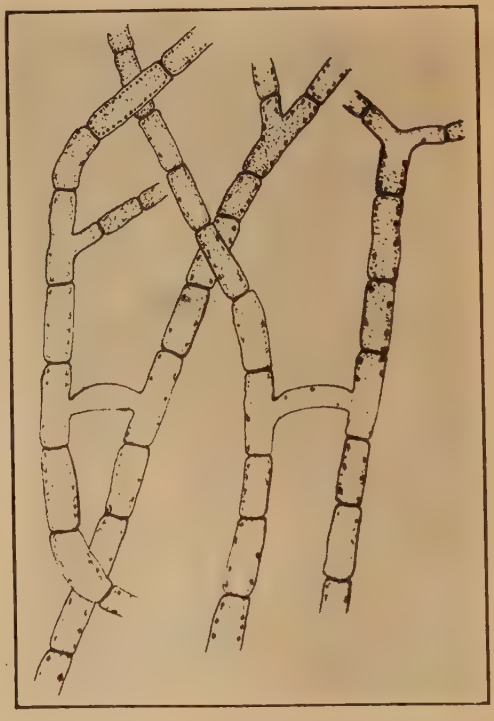

Fig. 6.—Camera lucida drawing of the mycelium

superficial mycelium was abundant at the place of inoculation and has penetrated the tissues which it was covering but has not spread any farther.

Sclerotia remain dormant in the soil until early summer when it is possible they may germinate giving rise to apothecia bearing ascospores. So far no apothecia has been observed by the writer in the development of the sclerotia.

The sclerotia may also live over winter in the soil and germinate by mycelium which can infect the plants, which has been shown above.

No definite name can yet be given to the fungus which causes this potato disease in New Brunswick, but on the results so far obtained and on the microscopical examination of the mycelium, it is identical with that of (*Sclerotinia libertiana Fckl.*) This is shown in Fig. 6. All tend to show that the fungus is *S. libertiana.*

Control

The only satisfactory means of control are crop rotation so that susceptible plants are not available to the fungus and careful removal and destruction of diseased plant parts.

ABSTRACTS OF CANADIAN PLANT PATHOLOGICAL LITERATURE

By A. W. McCallum, Division of Botany, C. E. F., Ottawa

The abstracts and references given herewith include the papers on plant pathology published in Canada during 1921. In addition, an attempt has been made to include those papers which have been omitted from previous lists. It is felt that the three bibliographies which have now been published contain a fairly complete list of all papers on plants pathology which have been published in Canada.

ANONYMOUS.—*Does it pay to spray?*—Ont. Dept. Agric. Spec. Bull. 1-8. 1897.

ANONYMOUS.—*Ann. Rept. of Supt. of Spraying for Ont.*—Ont. Dept. Agric. 1-16. 1898.

ANONYMOUS.—*Discussion on decay in timber.*—Trans. Can. Soc. Civ. Eng. 29 (part 1): 324-365. 20 fig. 1915.—This discussion by a number of engineers deals with conditions, forms and results of attacks on various kinds of structural timber by fungi, more particularly by *Merulius lachrymans, Coniophora cerebella, Trametes serialis* and other unidentified forms.

ANONYMOUS.—*White Pine Blister Rust.*—Ann. Rept. Min. Lands, Forests and Mines, Ont. 1916: 147-149. 1 pl. 1917.—Presents the life history of the rust together with an account of its distribution in Ontario.

ANONYMOUS.—*Canadian Branch of the American Phytopathological Society.* Sci. Agric. 1: 18. 1921.—An account of the second annual meeting of the Canadian Branch.

BEDFORD, S. A.—*Preventives of Smut in Wheat.* Central Exp. Farms Rept. 324-325. 1905.

BETHUNE, C. J. S.—*Orchard Diseases.* 35th Ann. Rept. Ont. Agric. Coll. and Exp. Farm for 1909: 34-36. 1910.

BISBY, G. R.—*Stem Rot of Sunflowers in Manitoba.* Sci. Agri. 2: 58-61. Fig. 1-3. 1921.—An undetermined species of *Sclerotinia*, causing a stem rot of the cultivated sunflower, appeared in Manitoba during 1920 and 1921. Symptoms are rotting of the stem, usually at the surface of the ground, and wilting of the plant. The fungus lives over winter in the soil and spreads rather rapidly.

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CAESAR, L.—*The most important diseases of currants and gooseberries.* Ont. Dept. Agric. Fruit Br. Bull. 222: 31-33. Fig. 17-19. 1914.

CAESAR, L.—*Apple Scab (Venturia pomi).* Fruit Growers Assoc. Ont. 45: 54-69. 3 figs. 1914.

CAESAR, L.—*Black knot of plums and cherries.* Can. Hort. 42: 281-282. 1 fig. 1919.

COWAN, P. R.—*Some Potato Problems.* 8th Ann. Rept. Que. Soc. Prot. Plants for 1914-1915: 116-120. 1915.

CUNNINGHAM, G. C.—*The White Pine Blister Rust.* Crown Lands Detp. N.B. Ann. Rept. 57: 103-106. Pl. 1-4. 1917.—Blister rust has not been found in New Brunswick yet though no systematic survey has been made for it.

DICKSON, B. T.—*Plant Diseases of 1920-21.* 13th Ann. Rept. Que. Soc. Prot. Plants for 1920-21: 66-67. 1921.

DICKSON, B. T.—*Report of the Delegate to the Canadian Branch of the American Phytopathological Society.* 13th Ann. Rept. Que. Soc. Prot. Plants for 1920-21: 20-23. 1921.—Presents abstracts of the papers given at the second annual meeting.

DICKSON, B. T.—*Diseases of the Potato.* Sci. Agric. 2: 55-57. Fig. 1-2. 1921.—The first of a series of papers upon potato diseases in which tipburn is described and the potato leaf hopper credited with causing this disease.

DICKSON, B. T.—*Diseases of the Potato.* Sci. Agric. 2: 93-96. Fig. 3-5. 1921.—An account of the symptoms, effects and control of mosaic and leaf roll.

DICKSON, B. T.—*Diseases (sic) of the Potato.* Sci. Agric. 2: 163-167. Fig. 6-9. 1922.—A description of the symptoms and control of powdery scab together with an account of the life history of the causal organism. Black leg is treated similarly.

DUFF, J. S.—*White pine blister rust.* Ann. Rept. Min. Agric. Ont. for 1915: 22-1916.—This disease is present in Brant, Durham, Halton, Kent, Lincoln, Wellington and Wentworth Counties.

EASTHAM, J. W. and J. E. HOWITT.—*Fungus diseases of vegetables.* Ont. Dept. Agric. Bull. 171: 37-62. 11 fig. 1909.

EASTHAM, J. W.—*Annual Report of Plant Pathologist.* 11th Ann. Rept. B. C. Dept. Agric. for 1916: 58-62. 1917.

EASTHAM, J. W.—*Annual Report of Provincial Plant Pathologist.* 12th Ann. Rept. B. C. Dept. Agric. for 1917: 51-56. 1918.

EASTHAM, J. W.—*Apple scab and its control.* Can. Hort. 41: 253-254. 1 fig. 1918.

EASTHAM, J. W.—*Report of the Provincial Plant Pathologist.* 13th Ann. Rept. B. C. Dept. Agric. for 1918: 32-36. 1 pl. 1919.

EASTHAM, J. W.—*Report of the Provincial Plant Patologist. Vancouver.* 15th Ann. Rept. B. C. Dept. Agric. for 1920: 51-55. 1 pl. 1921.

FAULL, J. H.—*Fomes officinalis (Vill.), A Timber Destroying Fungus.* Trans. Royal Can. Inst. 11: 185-209. Pl. 18-25. 1 fig. 1916.—Presents the results of a study of this interesting fungus which has been known and used medicinally since the time of Dioscorides. The active principle is a resinous substance, agaricin, which, with other resins, may form as much as 70% of the dry weight of the fruiting body. It has been believed by certain European mycologists

that this form and *Polyporus sulphureus* were closely related. This view, however, is shown to be erroneous. The gross and histological features of the decay produced by this fungus, together with an account of its distribution and hosts, are also described.

FAULL, J. H.—*Preliminary Report: In Report of the Forestry Branch, 1918.* Ann. Rept. Min. of Lands ,Forests and Mines, Ont. for 1917-1918: 156-160. 1919.—An introductory note on needle blight of white pine, a disease which is characterized by the progressive reddening of the new leaves as they unfold from the buds until from one to two thirds of the total length at maturity are involved. Several hundred diseased trees were marked for further study.

FAULL, J. H.—*Report for 1919.* Ann. Rept. Min. Lands, Forests and Mines, Ont. for 1918-1919: 119-125. 1920.—Observations made on coniferous trees at a distance of four to six miles from winter roasting beds indicate that no injury occurs in winter from sulphur fumes. Analysis of the results obtained from a study of marked trees indicated that blighted young white pines usually recover while a variable percentage of older trees also recover but more slowly. The mortality in old trees is about 5%. In an endeavour to determine the cause of needle blight several hundred inoculations, using juice from diseased foliage, were made on healthy twigs of healthy trees. No infection resulted, however. The root systems of several small, blighted trees were next examined. This revealed the seat of the trouble. The main branches of these root systems were in most cases killed back from 4-12 inches or more from the tips and few of the laterals appeared very healthy. In contrast the root systems of young, healthy trees were normal. The leaf injury, then, is due to the fact that, in early summer, when there is a sudden increase in the water requirements of the tree the roots are unable to supply it. The cause of the root injury is, as yet, unknown though drought seems the most likely explanation. A list of tree diseases observed in Northern Ontario is appended.

FAULL, J. H.—*Forest Pathology In Report of The Forestry Branch, 1920.* Ann. Rept. Min. Lands and Forests, Ont. for 1919-1920: 224-235. 9 fig. 1921.—Continuing the study of white pine needle blight, observations on marked trees indicate that affected trees up to six in diameter are likely to recover but the death rate in older trees is much higher with recovery more uncertain and slower. Temperature records show that frost is not a factor in the occurrence of blight. Winter browning of the foliage of coniferous trees was very prevalent in 1920. In some cases trees were killed outright and in other twigs and small branches as well as foliage suffered. This injury is usually localized, occurring on the south side of the tree and in the lower portion of the crown. It is due to transpiration occurring when the ground is frozen and the roots are unable to replace the water given off by the leaves. "Red branch" of balsam is ascribed to insect wounding of the bark late in the season followed by winter frosts. A twig blight of balsam and canker of poplar are also mentioned together with a preliminary note on heart rots of coniferous trees.

FLETCHER, J.—*Smuts in small grain.* Central Exp. Farms Rept. 141-142. 1 fig. 122-124. 3 fig. 1895.

FRASER, W. P.—*Notes of Some Plant Diseases of 1913.* 6th Ann. Rept. Que. Soc. Prot. Plants for 1913-1914: 45-50. 3 fig. 1914.

FRASER, W. P.—*Storage Rots of Potatoes and Other Vegetables.* 6th Ann. Rept. Que. Soc. Prot. Plants for 1913-1914: 50-51. 1914.

FRASER, W. P.—*The Cereal Rusts.* 7th Ann. Rept. Que. Soc. Prot. Plants for 1914-1915: 116-120. 1915.

FRASER, W. P.—*Plant Disease Investigations in Western Canada.* Agric. Gaz. Can. 8: 318-320. 1921.—Systematic work in plant pathology was begun in Western Canada in 1917, when an agreement was reached whereby the Dominion Government appointed and paid the investigators while the universities and agricultural colleges provided laboratory and greenhouse facilities. Most of the work to date has been in connection with stem rust of wheat although smut of western rye grass and stripe disease of barley have also been investigated. Eight strains of stem rust have been separated and plant breeding for rust resistance is being carried on at the University of Saskatchewan. This is the line of research which is most promising of results in combatting the rust.

FRENCH, P. E.—*Experimental work.* B. C. Dept. Agric. Ann. Rept. 12: 24-28. 1917.

GORHAM, R. P.—*Powdery scab of the potato.* Dept. Agric. N. B. Hort. Div. Leaflet 3: 1-6. 3 fig. 1914.

HARRISON, F. C.—*Fungous Diseases.* 21st Ann. Rept. Ont. Agric. Coll. and Exp. Farm for 1895: 187-188. 2 fig. 1896.

HARRISON, F. C.—*Report of the Bacteriologist.* 23rd Ann. Rept. Ont. Agric. Coll. and Exp. Farm for 1897: 121-128. 2 fig. 1898.

HEARST, W. H.—*Experimental Work.* Rept. Min. Agric. Ont. 60-62. 1917.—Several extracts from the report of the Vegetable Specialist.

HENRY, G. S.—*Experimental Work.* Rept. Min. Agric. Ont. 1918.—Several notes of interest appear in this report. These are: Potato Investigational work, 19-20, Winter Injury to Fruit Trees, 20-21, and Potato Demonstrations, 72-78.

HOCKEY, J. F.—*Germination of Teliospores of Puccinia Antirrhini.* 13th Ann. Rept. Que. Soc. Prot. Plants for 1920-1921: 54-57. 1 fig. 1921.—An account of a successful attempt to germinate the teleutospores of the snapdragon rust. Germination is apparently favoured by exposure to low temperatures.

HOWITT, J. E.—*Fungus Diseases.* 38th Ann. Rept. Ont. Agric. Coll. and Exp. Farm from for 1912: 29-31. 1913.—Some ginseng diseases mentioned.

HOWITT, J. E.—*Raspberry yellows and cane blight.* Can. Hort. 36: 237-238. 1913.

HOWITT, J. E. and L. CAESAR.—*The more important fruit tree diseases of Ontario.* Ont. Dept. Agric. Bull. 257: 1-44. Fig. 1-31. 1917.—A publication for fruit growers. It is aimed to enable them to recognize and treat the serious fruit tree diseases which occur in Ontario. These are all described and control measures given for each. A spray calendar is appended.

HOWITT, J. E.—*Experiments in the Control of Rhizoctonia or Black Scurf of Potatoes.* Sci. Agric. 1: 256. 1921.—The results of experiments during two years in the control of rhizoctonia indicate that corrosive sublimate of strength 1 in 500 for two hours gives perfect control.

HAY, B.—*Experimental Work.* 12th Ann. Rept. B. C. Dept. Agric. for 1917. 29-30. 1918.

HUTCHINGS, C. B.—*The Black Knot of Plum and Cherry.* 8th Ann. Rept. Que. Soc. Prot. Plants for 1915-1916: 85-88. 1 fig. 1916.

JONES, D. H.—*Fire Blight and Alfalfa Leaf Spot.* 36th Ann. Rept. Ont. Agric. Coll. and Exp. Farm for 1910: 163-168. 1 pl. 2 fig. 1911.

JONES, D. H.—*Tomato blight.* Ont. Veg. Growers' Assoc. Ann. Rept. 11:60-67. 2 fig. 1915.

KYNOCH, W. and R. J. BLAIR.—*Is Wood a Suitable Material for the Construction of Mill Buildings?* Contract Record. Aug. 7: 622. 1918. Construction. Aug. 249. 1918. Canada Lumberman and Woodworker. Oct. 15: 31. 1918. Canadian Engineer. Aug. 1: 95. 1918.

KYNOCH, W. and J. A. CODERRE.—*Creosote Treatment of Jack Pine and Eastern Hemlock for Cross-ties.* Canada, Dept. of Interior, Forestry Branch Bull. 67: 1-24. Pl. 1-8. Fig. 1-2. 1919.

LÉTOURNEAU, F.—*Fire Blight.* 8th Ann. Rept. Que. Soc. Prot. Plants for 1915-1916: 42-45. 1916.

LOCHHEAD, W.—*The Story of Spraying Mixtures.* 13th Ann. Rept. Que. Soc. Prot. Plants for 1920-1921: 12-19. 1921.—The presidential address before the thirteenth annual meeting.

MACOUN, W. T.—*Winter injury to fruit trees in Canada 1917-18.* Ann. Rept. Pomol. and Fruit Growing Soc. Que. 31-34. 1918.

MAHEUX, GEORGES.—*Some Methods of Seed Treatment.* 13th Ann. Rept. Que. Soc. Prot. Plants for 1920-1921: 47-50. 1921.

McCallum, A. W.—*Abstracts of Canadian Plant Pathological Literature.* Sci. Agric. 1: 78-80. 1921.—Abstracts of papers on plant pathology published in Canada during 1919 and 1920.

McCready, S. B.— *Fungi and Plant Pathology.* 36th Ann. Rept. Ont. Agric. Coll. and Exp. Farm for 1910: 37-47. 6 fig. 1911.

McCubbin, W. A.—*White pine blister rust on currants.* Can. Hort. 40: 34. 1 fig. 1917.

McRostie, G. P.—*The Immunization of Plants.* Sci. Agric. 1: 122-124. 1921.—Advocates the production of resistant varieties as the logical means of combatting plant diseases.

Middleton, M. S.—*Plant diseases.* 12th Ann. Rept. B. C. Dept. Agric. for 1917: 20-21. 1918.

Mitchell, W. G.—*Treated Wood Block Paving.* Canada, Dept. of Interior, Forestry Branch Bull. 49: 1-40. 20 fig. 1915.

Mitchell, W. G.—*The Preservative Treatment of Timber.* Canada Lumberman and Woodworker. June 15: 34. 1916.

Murphy, P. A.—*The black leg disease of potatoes caused by Bacillus solanisaprus.* Dom. Exp. Farms Bot. Circ. 11: 1-8. Fig. 1-6. 1916.—A brief description of the symptoms and injuries due to black leg together with the life history and control of the causal organism.

Murphy, P. A.—*Late blight and rot of potatoes caused by the fungus Phytophthora infestans.* Dom. Exp. Farms Bot. Circ. 10: 1-13. Fig. 1-2. 1916.—Life history of the fungus with symptoms and control of the disease caused by it.

Murphy, P. A.—*Potato Spraying in Prince Edward Island.* Ann. Rept. Dept. Agric. P. E. I. 98-103. 1 pl. 1917.

Murphy, P. A.—*Some constitutional diseases of the potato.* Can. Hort. 42: 9. 1919.

Murphy, P. A.—*Investigation of Potato Diseases.* Canada, Dept. of Agric. Dom. Exp. Farms Bull. 44 (2nd series.) 1-86. Fig. 1-34. 1921.—This bulletin embodies the results of the author's extensive investigations on potato diseases. The following diseases are treated very fully—late blight, black leg, leaf roll, mosaic, curly dwarf and related troubles. A comprehensive bibliography is appended.

Newton, Margaret A.—*A Preliminary Report on the Occurrence of Biologic Forms of Wheat Stem Rust in Western Canada.* Sci. Agric. 1: 213. 1921.—Until 1916 only one biologic form of stem rust was known to occur on wheat. To date eleven strains have been isolated in Canada. Among these there are no new forms, all of them having been described by Stakman. Breeding resistant varieties seems to be the most promising method of controlling rust but before this can be done effectively more must be known of the number, characteristics and distribution of the biologic forms in Canada.

Panton, J. H.—*Plant Diseases.* 20th Ann. Rept. Ont. Agric. Coll. and Exp. Farm for 1894: 7, 8, 13, 17, 18. 9 fig. 1895.

Panton, J. H.—*Instructions for spraying.* Rept. Dept. Agric. N. B. 209-222. 13 fig. 1897.

Petch, C. E.—*Spraying vs Dusting.* Sci. Agric. 1: 171-172. 1921.—The writer has found dusting to be as efficient as spraying in the control of apple scab and biting insects though not in the control of sucking insects. It is more easily applied and is as cheap.

Robertson, R.—*Experiments to prevent smut in oats and barley.* Dom. Exp. Farms Rept. 283-285. 1900.

Roy, J. A.—*Methods of Prolonging the Durability of Fence Posts.* 13th Ann. Rept. Que. Soc. Prot. Plants for 1920-1921: 57-65. 1921.—Describes a number of different treatments and gives the approximate cost of each.

Sanders, G. E. and A. Kelsall.—*Dusts and Dusting for Insect and Fungus Control. Part I. The Present Status of Dusting.* Sci. Agric. 1: 14-18. 1921.—A discussion of the relative merits

of dusting and spraying reaching the conclusion that as far as the orchard is concerned the former is on the whole more satisfactory.

SANDERS, G. E. and A. KELSALL.—*Dusts and Dusting for Insect and Fungus Control. II. Dusts containing Copper and Arsenic.* Sci. Agric. 2: 7-14. 1921.—A consideration of the properties of copper-arsenic dust which was first used in 1917. The writers conclude that this or some other similar dust will be an important factor in controlling plant pests.

SANDERS, G. E. and A. KELSALL.—*Spraying vs Dusting.* Agric. Gaz. Can. 8: 134-136. 1921.

SAUNDERS, W.—*Spraying for rust.* Dom. Exp. Farms Rept. 33. 1893.

SHARPE, T. A.—*Bordeaux mixture for potato rot.* Dom. Exp. Farms Rept. 336. 1893.

SHUTT, F. T.—*Chemistry of the copper and salt fungicides.* Dom. Exp. Farms Rept. 171-175 1894.

TICE, C.—*Seed Potato Certification in British Columbia.* Agric. Gaz. Can. 8: 448-450. 1921.

WINSLOW, R. M.—*Apple scab control in British Columbia.* Can. Hort. 40: 56-58. 1 fig. 1917.

WHETZEL, H. H.—*The Present Status of Plant Pathology in Agriculture.* 13th Ann. Rept Que. Soc. Prot. Plants for 1920-1921: 24-30. 1921.—An address given before this society.

ZAVITZ, C. A.—*Treatment of Smut.* 23rd Ann. Rept. Ont. Agric. Coll. and Exp. Farm for 1897: 170. 1898.

ZAVITZ, C. A.—*Cereal and Potato Diseases.* 31st Ann. Rept. Ont. Agric. Coll. and Exp. Farm for 1905: 182-185, 199-201. 1906.

ZAVITZ, C. A.—*Treatment of Grain for Smut.* 33rd Ann. Rept. Ont. Agric. Coll. and Exp. Farm for 1907: 179-181. 1908.

ZAVITZ, C. A.—*Treatment of Grain for Smut.* 34th Ann. Rept. Ont. Agric. Coll. and Exp. Farm for 1908: 183-185. 1909.

ZAVITZ, E. J.—*Tree Diseases.* Ann. Rept. Minister Lands, Forests and Mines, Ont. for 1916-1917: 155-158. 1918.—Gives the distribution of the blister rust in Ontario together with measures to be adopted respecting it.

ZAVITZ, E. J.—*Tree Diseases.* Ann. Rept. Min. Lands, Forests and Mines, Ont. for 1917-1918: 155-156. 1919.—Reports the eradication of *Ribes* from the Provincial Forest Station in Norfolk County. Four men worked for four months to do this work on an area of about 100 acres. This indicates the difficulty of such control measures on large areas of land.

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